

Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) EP 1 043 189 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.10.2000 Bulletin 2000/41

(51) Int. Cl.⁷: B60Q 1/26

(21) Application number: 00107296.6

(22) Date of filing: 04.04.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 06.04.1999 US 127959

(71) Applicant:
911 Emergency Products, Inc.
St. Cloud, MN 56303 (US)

(72) Inventor: Pederson, John C.
St. Cloud, MN 56303 (US)

(74) Representative:
Patentanwälte
Hauck, Graalfs, Wehnert,
Döring, Siemons
Neuer Wall 41
20354 Hamburg (DE)

(54) Replacement led lamp assembly and modulated power intensity for light source

(57) A light emitting diode (LED) warning signal light, the warning signal light comprising an array of light sources configured on a light support and in electrical communication with a controller and a power supply, battery, or other electrical source. The warning signal light provides various colored light signals for independent use or use by an emergency vehicle. These light signals may include a stationary light, strobe light, revolving light, an alternating light, a flashing light, and an oscillating light. Additionally, the warning signal light may be capable of displaying symbols, reverse characters, or arrows. Preferably, rotating and oscillating light

signals are produced by sequentially illuminating columns of LED's on a stationary light support. However, the warning signal light may also be rotated or oscillated via mechanical means. The warning signal light may also be transportable for easy connection to a stand such as a tripod for electrical connection to a power supply as a stand-alone warning signal. The controller may further be adapted to regulate or modulate the power intensity exposed to the illuminated LED's to create a variable intensity light signal.

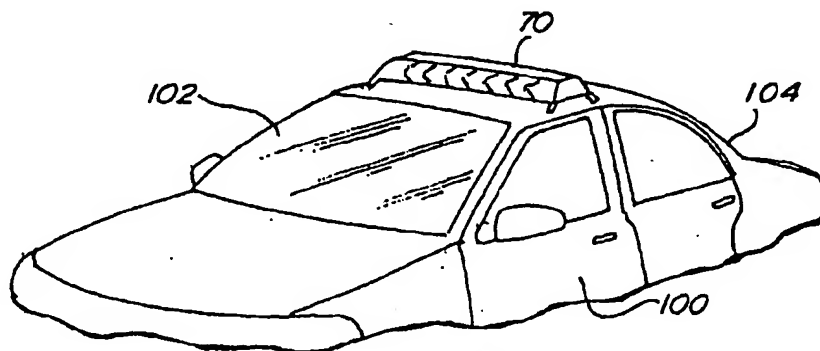


Fig. 1.

EP 1 043 189 A2

Description

[0001] The present invention relates to a light emitting diode (LED) warning signal light having modulated power intensity for use by emergency vehicles and is based upon Provisional U.S. Patent Application No. 60/127,959, filed April 6, 1999, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Light bars or emergency lights of the type used on emergency vehicles such as fire trucks, police cars, and ambulances, utilize warning signal lights to produce a variety of light signals. These light signals involve the use of various colors and patterns. Generally, these warning signal lights consist of revolving and oscillating lamps having reflective back support members and colored filters.

[0003] Many problems exist with the known methods for producing warning light signals. One particular problem with known light bars is their reliance on mechanical components to revolve or oscillate the lamps to produce the desired light signal. Additionally, these components increase the size of the light bar or emergency lights which may adversely affect the vehicles aerodynamic characteristics. Moreover, there is an increased likelihood that a breakdown of the light bar will occur requiring the repair or replacement of the defective component. Finally, the known light bars require a relatively large amount of electrical current during operation. The demands upon the electrical power system for a vehicle may therefore exceed available electrical resources reducing optimization of performance.

[0004] The most common light sources being used in light bars or emergency lights include halogen lamps or gaseous discharge xenon lamps. These lamps emanate large amounts of heat which is difficult to dissipate from a sealed light bar or emergency light and which may damage the electronic circuitry contained therein. In addition, these lamps consume large amounts of current requiring a large power supply or large battery or electrical source which may be especially problematic for use with a vehicle. These lamps also generate substantial electromagnetic emissions which may interfere with radio communications. Finally, these lamps, which are not rugged, have relatively short life cycles necessitating frequent replacement.

[0005] Another problem with the known warning signal lights is the use of filters to produce a desired color. Filtering techniques produce more heat that must be dissipated. Moreover, changing the color of a light source requires the physical removal of the filter from the light bar or emergency light and the insertion of a new filter. Furthermore, filters fade or flake rendering the filters unable to consistently produce a desired color for observation in an emergency situation.

[0006] These problems associated with traditional signaling lamps are exacerbated by the fact that creating multiple light signals requires multiple signaling lamps. Further, there is little flexibility in modifying the light signal created by a lamp. For example, changing a stationary lamp into one that rotates or oscillates would require a substantial modification to the light bar which may not be physically or economically possible.

[0007] The present invention relates to electrical lamps; more particularly, the invention relates to high brightness light-emitting diode or "LED" technology which operate to replace gaseous discharge or incandescent lamps as used as automotive turn signals, brake lights, and/or back-up light sources.

[0008] Illumination lamps for automobile turn signals, brake lights, back-up lights, and/or marker lights/headlights frequently have accompanying utility parabolic lens/reflector enclosures which have been used for utility warning signals or emergency vehicle traffic signaling.

[0009] These signaling devices as known are commonly referred to as "unmarked corner tubes," "hide-a-way tubes," or "dome tubes" ("Hide-a-Way Tubes" is a trade name of the Whelan Engineering Company). These signaling devices as known frequently utilize xenon gaseous discharge tubes or incandescent lamps as the illumination sources.

[0010] A problem with the prior art is the cost and failure rate of the known "unmarked corner tubes," "hide-a-way tubes," or "dome lights." The failure rate of these devices frequently results in significant amounts of "down time" for a vehicle to effectuate replacement. Further, an officer is frequently unaware that a vehicle light is inoperative requiring replacement. This condition reduces the safety to an officer during the performance of his or her duties. In addition, the reduced life cycle and failure rate of the known illumination devices significantly increases operational costs associated with material replacement and labor. A need, therefore, exists to enhance the durability, and to reduce the failure rate, of illumination devices while simultaneously reducing the cost of a replacement illumination source.

[0011] In the past, the xenon gaseous discharge lamps have utilized a sealed compartment, usually a gas tube, which may have been filled with a particular gas known to have good illuminating characteristics. One such gas used for this purpose was xenon gas, which provides illumination when it becomes ionized by the appropriate voltage application. Xenon gas discharge lamps are used in the automotive industry to provide high intensity lighting and are used on emergency vehicles to provide a visible flashing emergency signal light.

[0012] A xenon gas discharge lamp usually comprises a gas-filled tube which has an anode element at one end and a cathode element at the other end, with both ends of the tube sealed. The anode and cathode elements each have an electrical conductor attached,

which passes through the sealed gas end of the lamp exterior. An ionizing trigger wire is typically wound in a helical manner about the exterior of the glass tube, and this wire is connected to a high voltage power source typically on the order of 10-12 kilowatts (kw). The anode and cathode connections are connected to a lower level voltage source which is sufficient to maintain illumination of the lamp once the interior gas has been ionized by the high voltage source. The gas remains ignited until the anode/cathode voltage is removed; and once the gas ionization is stopped, the lamp can be ignited again by reapplying the anode/cathode voltage and reapplying the high voltage to the trigger wire via a voltage pulse.

[0013] Xenon gas lamps are frequently made from glass tubes which are formed into semicircular loops to increase the relative light intensity from the lamp while maintaining a relatively small form factor. These lamps generate extremely high heat intensity as well as light intensity, and therefore, require positioning of the lamps so as to not cause heat buildup in nearby components. The glass tube of a xenon lamp is usually mounted on a light-based pedestal which is sized to fit into an opening in the light fixture and to hold the heat generating tube surface in a light fixture compartment which is separated from other interior compartment surfaces. In a vehicle application, the light and base pedestal are typically sized to fit through an opening in the light fixture which is about 1 inch in diameter. The light fixture component may have a glass or plastic cover made from colored material so as to produce a colored lighting effect when the lamp is ignited. Xenon gas discharge lamps naturally produce white light, which may be modified to produce a colored light, of lesser intensity, by placing the xenon lamp in a fixture having a colored lens. The glass tube of the xenon lamp may also be painted or otherwise colored to produce a similar result, although the light illumination from the tube tends to dominate the coloring; and the light may actually have a colored tint appearance rather than a solid colored light. The color blue is particularly hard to produce in this manner.

[0014] Because a preferred use of xenon lamps is in connection with emergency vehicles, it is particularly important that the lamp be capable of producing intense coloring associated with emergency vehicles, i.e., red, blue, amber, green, and clear.

[0015] When xenon lamps are mounted in vehicles, some care must be taken to reduce the corroding effects of water and various chemicals, including road salt, which might contaminate the light fixture. Corrosive effects may destroy the trigger wire and the wire contacts leading to the anode and cathode. Corrosion is enhanced because of the high heat generating characteristics of the lamp which may heat the air inside the lamp fixture when the lamp is in use, and this heated air may condense when the lamp is off to buildup moisture inside the fixture. The buildup of moisture may result in

the shorting out of the electrical wires and degrade the performance of the emission wire, sometimes preventing proper ionization of the gas within the xenon gas discharge lamp.

[0016] Warning lights, due to the type of light source utilized, may be relatively large in size which in turn may have adverse affects upon adjacent operational components. In addition, there is an increased likelihood for a breakdown requiring repair or replacement of enlarged components.

[0017] The known warning signal lamps generally emanate large amounts of heat which is difficult to dissipate from the sealed light bar or emergency light area and may damage the electronic circuitry contained therein.

[0018] Another problem with the known warning signal lights is the use of rotational and/or oscillating mechanisms which are utilized to impart a rotational or oscillating movement to a light source for observation during emergency situations. These mechanical devices are frequently cumbersome and difficult to incorporate and couple into various locations about a vehicle due to the size of the device. These mechanical devices also frequently require a relatively large power supply to engage and operate the device to impart rotational and/or oscillating movement for a light source. Power consumption of electrical components for an emergency vehicle is of primary consideration for vehicle operators.

[0019] Another problem with the known warning signal lights is the absence of flexibility for the provision of variable intensity for the light sources to increase the number of available distinct and independent visual light effects. In certain situations it may be desirable to provide a variable intensity for a light signal or a modulated intensity for a light signal to provide a unique light effect to facilitate observation by an individual. In addition, the provision of a variable or modulated intensity for a light signal may further enhance the ability to provide a unique desired light effect for observation by an individual.

[0020] No warning lights are known which are flexible and which utilize a variable light intensity to modify a standard lighting effect. The warning lights as known are generally limited to a flashing light signal. Alternatively, other warning signal lights may provide a sequential illumination of light sources. No warning or utility light signals are known which simultaneously provide for modulated and/or variable power intensity for a known type of light signal to create a unique and desirable type of lighting effect.

[0021] No warning signal lights are known which provide an irregular or random light intensity to a warning signal light to provide a desired lighting effect. Also, no warning light signals are known which provide a regular pattern of variable or modulated light intensity for a warning signal light to provide a desired type of lighting effect. Further, no warning light signals known which

combine a type of light effect with either irregular variable light intensity or regular modulated light intensity to provide a unique and desired combination lighting effect.

[0022] It may also be necessary to provide alternative colored LED light sources which may be electrically controlled for the provision of any desired pattern of light signals such as flashing, oscillating, modulating, rotational, alternating, and/or strobe light effects without the necessity of spatially inefficient and bulky mechanical rotational devices. In this regard, a need exists to provide a spatially and electrically efficient LED light source for use on an emergency or utility vehicle which provides the appearance of rotation without the necessity of a mechanical rotational device. In addition, a need exists to provide a spatially and electrically efficient LED light source for use on an emergency vehicle which provides a flashing, modulated, oscillating, rotational, alternating, and/or strobe light effects without the necessity of mechanical devices.

[0023] In view of the above, there is a need for a warning signal light that:

- (1) Is capable of producing multiple light signals;
- (2) Produces the appearance of a revolving or oscillating light signal without relying upon mechanical components;
- (3) Generates little heat;
- (4) Uses substantially less electrical current;
- (5) Produces significantly reduced amounts of electromagnetic emissions;
- (6) Is rugged and has a long life cycle;
- (7) Produces a truer light output color without the use of filters;
- (8) Reduces current draw upon an emergency vehicle power supply;
- (9) Is positionable at a variety of locations about an emergency vehicle; and
- (10) Provides variable power intensity to the light source without adversely affecting the vehicle operator's ability to observe objects while seated within the interior of the vehicle

GENERAL DESCRIPTION OF THE INVENTION

[0024] According to the invention, there is provided a light emitting diode (LED) warning signal light which may be depicted in several embodiments. In general, the warning signal light may be formed of an array of light sources configured on a light support and in electrical communication with a controller and a power supply, battery, or other electrical source. The warning signal light may provide various colored light signals for use by an emergency vehicle. These light signals may include a stationary light, a strobe light, a revolving light, a flashing light, a modulated or variable intensity light, an oscillating light, an alternating light, and/or any combination thereof. Additionally, the warning signal light

may be capable of displaying symbols, characters, or arrows. Preferably, rotating and oscillating light signals are produced by sequentially illuminating columns of LED's on a stationary light support. However, the warning signal light may also be rotated or oscillated via mechanical means. The warning signal light may also be transportable for easy connection to a stand such as a tripod for electrical connection to a power supply, battery, or other electrical source as a remote stand-alone signaling device.

[0025] For the replacement LED lamp, extending from the standard mounting base may be a light source which one or a plurality of LED lamp modules which may be formed of the same or different colors as desired by an individual. Additionally, rotating and oscillating light signals may be produced by substitution of an LED light source in an oscillating or reflective light assembly. In addition, the warning signal light and/or replacement warning signal light may be electrically coupled to a controller used to modulate the power intensity for the light sources to provide for various patterns of illumination to create an illusion of rotation or other type of illusion for the warning signal light without the use of mechanical devices for rotation and/or oscillation motion.

[0026] It is also necessary to provide alternative colored LED light sources which may be electrically controlled for the provision of any desired pattern of light signals such as flashing, oscillating, modulating, rotational, alternating, and/or strobe light effects without the necessity of spatially inefficient and bulky mechanical rotational devices. In this regard, a need exists to provide a spatially and electrically efficient LED light source for use on an emergency vehicle which provides a desired appearance without the necessity of a mechanical device. In addition, a need exists to provide a spatially and electrically efficient LED light source for use on an emergency vehicle which provides a flashing, modulated, oscillating, alternating and/or strobe light effect without the necessity of mechanical devices.

[0027] Alternatively, the reflective light assembly may be stationary. The reflective light assembly may also rotate about a stationary light source. In another alternative embodiment, the reflective assembly may be positioned at an acute angle approximately 45° above a stationary LED panel or a solitary light source where the reflector is rotated about a pivot point and axis to create the appearance of rotation for the light source. The light source may be utilized in conjunction with the reflective assembly and may also be electrically coupled to a controller for the provision of pulsating, variable, and/or modulated light intensity for observation by an individual.

[0028] The controller is preferably in electrical communication with the power supply and the LED's to modulate the power intensity for the LED light sources for variable illumination of the LED light sources to provide for the appearance of rotation, pulsation, oscillation,

strobe, flashing, alternating, and/or stationary light without the necessity for mechanical devices.

[0029] An advantage of the present invention is to provide a warning signal light capable of simulating a revolving or oscillating light signals without the use of mechanical components.

[0030] Another advantage of the present invention is that the warning signal light is capable of producing several different types of light signals.

[0031] Still another advantage of the present invention is to be rugged and have a relatively longer life cycle than traditional warning signal lights.

[0032] Still another advantage of the present invention is to produce a truer or pure light output color without the use of filters.

[0033] Still another advantage of the present invention is to allow the user to adjust the color of the light signal without having to make a physical adjustment from a multi-colored panel.

[0034] Still another advantage of the present invention is that it may be formed into various shapes. This allows the invention to be customized for the particular need.

[0035] Still another advantage of the present invention is that the light signal produced may be easily customized by the user via a controller or microprocessor.

[0036] Still another principal advantage of the present invention is the provision of an LED light source which is formed of a relatively simple and inexpensive design, construction, and operation and which fulfills the intended purpose without fear of failure or injury to persons and/or damage to property.

[0037] Still another principal advantage of the present invention is the provision of an LED light source which is flexible and which may easily replace existing illumination devices used as turn signals, brake lights, back-up lights, marker lights, and headlights in utility lens/reflector enclosures.

[0038] Still another principal advantage of the present invention is the provision of an LED light source for creation of bright bursts of intense colored light to enhance the visibility and safety of a vehicle in an emergency signaling situation.

[0039] Still another principal advantage of the present invention is the provision of an LED light source which is flexible and may easily replace existing illumination devices at a much more economic expense and further having a reduced failure rate.

[0040] Still another principal advantage of the present invention is the provision of an LED light source which produces brilliant lighting in any of the colors associated with an emergency vehicle light signal such as red, blue, amber, green, and/or white.

[0041] Still another principal advantage of the present invention is the provision of an LED light source which is highly resistant to corrosive effects and which is impervious to moisture build-up.

[0042] Still another principal advantage of the

present invention is the provision of an LED light source which has an extended life cycle and continues to operate at maximum efficiency throughout its life cycle.

[0043] Still another principal advantage of the present invention is the provision of an LED light source which draws less current and/or has a reduced power requirement from a power source for a vehicle.

[0044] Still another principal advantage of the present invention is the provision of an LED light source having improved reliability as compared to xenon gaseous discharge lamps and/or incandescent lamps as currently used on emergency vehicles.

[0045] Still another principal advantage of the present invention is the provision of an LED light source which is simple and may facilitate the ease of installation and replacement of a xenon and/or incandescent light source from a motor vehicle.

[0046] Still another principal advantage of the present invention is the provision of an LED light source which reduces RF emissions which may interfere with other radio and electronic equipment in an emergency vehicle.

[0047] Still another principal advantage of the present invention is the provision of an LED light source which functions under cooler operating temperatures and conditions thereby minimizing the exposure of heat to adjacent component parts which, in turn, reduces damage caused by excessive heat.

[0048] Still another principal advantage of the present invention is the provision of an LED light source having simplified circuitry for operation as compared to xenon gaseous discharge lamps and/or incandescent lamps as used with an emergency vehicle.

[0049] Still another principal advantage of the present invention is the provision of an LED light source which is flexible and which may be connected to a modulated power source to modulate the power intensity for the light source to provide the appearance of rotation and/or oscillation without the use of mechanical rotational or oscillating devices.

[0050] Still another principal advantage of the present invention is the provision of a warning signal light which may be easily visualized during emergency situations thereby enhancing the safety of emergency personnel.

[0051] Still another principal advantage of the present invention is the provision of a warning signal light which includes LED technology and which is operated by a controller to provide any desired type or color of light signal including but not limited to rotational, pulsating, oscillating, strobe, flashing, alternating, and/or stationary lights without the necessity for mechanical devices.

[0052] Still another principal advantage of the present invention is the provision of a warning signal light which is capable of simultaneously producing several different types of light signals.

[0053] A feature of the invention is a plurality of light

emitting diodes (LED's), integral to a circuit board, where the LED's are aligned in vertical columns and horizontal rows.

[0054] Another feature of the invention is the mounting of a panel of LED's to a mechanical device which rotates or oscillates the panel during use as a warning signal light on an emergency vehicle.

[0055] Yet another feature of the invention is the provision of a plurality of LED's mounted to a flexible circuit board which may be manipulated into any desired configuration and which may be used as a stationary, rotating, or oscillating signal light by an emergency vehicle.

[0056] Yet another feature of the invention is the provision of an LED support member supporting an array of colored LED's and a controller capable of selectively illuminating the LED's of the same color to produce a single or mixed colored light signal.

[0057] Still another feature of the invention is the provision of a light emitting diode support member having an array of LED's disposed about a front surface consisting of at least two sides and a controller capable of producing light signals on each side which are independent of each other.

[0058] Still another feature of the invention is the provision of an LED support member having an array of LED's angularly offset with respect to the LED support member for the provision of a horizontal light signal as viewed by an individual when the LED support member is mounted within the interior of the forward or rear windshield of a vehicle.

[0059] Still another feature of the invention is the provision of an LED support member which may be easily connectable and/or removed from a transportable support such as a tripod for placement of an LED warning signal light at any location as desired by an individual.

[0060] Still another feature of the invention is the provision of an LED support member which may be easily connectable to an emergency vehicle, including but not limited to automobiles, ambulances, trucks, motorcycles, snowmobiles, and/or any other type of vehicle in which warning signal or emergency lights are utilized.

[0061] Still another feature of the present invention is the provision a base having one or more LED's mounted thereon where said base is adapted for insertion into a standard one inch opening presently used for receiving xenon strobe tubes as a replacement LED warning light signaling light source.

[0062] Still another feature of the present invention is the provision a base having one or more LED's mounted thereon which is adapted for insertion into a mechanical device which rotates or oscillates a light source during use as a warning signal light on an emergency vehicle.

[0063] Still another feature of the present invention is the provision a microprocessor/controller which is in electrical communication with the LED light signal to

selectively activate individual LED's to produce a flashing, strobe, alternating, rotating, oscillating, pulsating, and/or stationary light signals.

[0064] Still another feature of the present invention is the provision a base having one or more LED's mounted thereon where the LED lamp modules are of the same or different colors for use as a light signal.

[0065] Still another feature of the present invention is the provision a controller capable of selectively activating individual LED's of the LED lamp module of the same or different colors to produce a single or mixed colored light signal.

[0066] Still another feature of the present invention is the provision an LED light signal which may be easily electrically coupled to a controller.

[0067] Still another feature of the present invention is the provision a warning signal light having a plurality of arrays of LED light sources affixed to the exterior of an emergency vehicle in electrical communication to each other.

[0068] Still another feature of the present invention is the provision a warning signal light having a controller in electrical communication with a plurality of arrays of LED warning signal lights or a single light sources for the provision of a modulated power intensity to create the appearance of rotational, pulsating, or oscillating motion for the light sources without the necessity for mechanical devices.

[0069] Still another feature of the present invention is the provision a warning signal light having a controller in electrical communication with a plurality of LED warning signal lights for the provision of modulated power intensity to establish the appearance of rotation, pulsation, or oscillation for the light sources without the necessity for mechanical devices.

[0070] Still another feature of the present invention is the provision an LED light source where the power may be modulated by the controller to produce variable power intensity for the light sources to provide various desired patterns of illumination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0071]

FIG. 1 is a partial perspective view of an emergency vehicle equipped with a light bar containing warning signal lights according to an embodiment of the invention;

FIG. 2 is a partial front elevation view of an emergency vehicle equipped with a light bar containing warning signal lights referring to an embodiment of the invention;

FIG. 3 is a perspective view of a warning signal light attached to a gyrator according to an embodiment of the invention;

FIG. 4 is a perspective view of a warning signal light according to an embodiment of the invention

depicting the sequential activation of columns of light-emitting diodes (LED's).

FIG. 5 is a perspective view of a warning signal light according to an embodiment of the invention depicting sequential activation of rows of LED's;

FIG. 6 is a perspective view of a warning light signal according to an embodiment of the invention;

FIG. 7 is a perspective view of a warning light signal according to an embodiment of the invention;

FIG. 8 is a perspective view of a warning light signal according to an embodiment of the invention;

FIG. 9 is a perspective view of a warning light signal according to an embodiment of the invention;

FIG. 10 is a perspective view of a warning light signal according to an embodiment of the invention;

FIGS. 1A, 11B, and 11C are schematic diagrams of the controller circuitry in accordance with an embodiment of the invention;

FIG. 12 is a perspective view of a warning signal light according to an embodiment of the invention;

FIG. 13 is a perspective detailed view of a warning signal light attached to the interior of a windshield of an emergency vehicle;

FIG. 14 is a side plan view of a warning signal light mounted to an interior surface of an emergency vehicle window having auxiliary offset individual LED light sources;

FIG. 15 is an environmental view of a warning signal light as engaged to a remote support device such as a tripod;

FIG. 16 is a detailed isometric view of a xenon strobe tube and standard mounting base;

FIG. 17 is a detailed isometric view of the replacement LED light source and standard mounting base;

FIG. 18 is a detailed isometric view of an incandescent lamp light source and standard mounting base;

FIG. 19 is a detailed isometric view of a replacement LED lamp and standard mounting base;

FIG. 20 is a front view of a standard halogen light source mounted in a rotating reflector;

FIG. 21 is a detailed rear view of a rotating reflector mechanism;

FIG. 22 is a detailed front view of the LED light source mounted to a rotating reflector;

FIG. 23 is a detailed front view of a replacement LED light source;

FIG. 24 is a detailed side view of a replacement LED light source; and

FIG. 25 is a detailed isometric view of a replacement LED light source and cover.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0072] A warning signal light according to the principles of the invention is indicated generally herein as

numeral 10. FIGS. 1 and 2 depict light bar 70 mounted to an emergency vehicle 104. Light bar 70 includes base 72, mounting means 74, cover 82, and warning signal lights 10. Also included in light bar 70 are gyrators 90 used to impart motion to warning signal lights 10.

[0073] Referring to FIGS. 3 and 9, warning signal light 10 comprises light support 12, light sources 30, controller 50 (shown in FIG. 11), and connecting portion 40 for attaching the warning signal light 10 to light bar 70 or gyrator 90. The warning signal light 10 operates to create a warning signal for use by an emergency vehicle 104 by selectively activating light sources 30 using controller 50. Alternatively, warning signal light 10 may be formed of a solitary LED light source 30 at the discretion of an individual.

[0074] Light sources 30 are preferably light emitting diodes (LED's) and are generally arranged in aligned columns 32 and rows 34 as shown in FIG. 7 and 9. Each of the light emitting diodes (LED's) may have shoulder portion 38 adjacent LED support 12 and dome 36. LED's 30 are situated to be in electric communication with controller 50 and a power supply, a battery, or power source. The use of light emitting diodes (LED's) to replace traditional halogen or gaseous discharge xenon lamps reduces heat generation, current draw, and electromagnetic emissions, while increasing lamp life and producing a more true output light color.

[0075] Controller 50, is used to selectively activate columns 32, rows 34, or individual LED's 30, to create a constant light signal, a strobe light signal, a pulsating light signal, a flashing light signal, the illusion of a rotating or an oscillating light signal, a reverse character message, or images such as arrows. FIGS. 11A, 11B, and 11C show an embodiment of controller 50 capable of selectively activating columns 32, rows 34 or individual LED's 30. Controller 50 generally comprises microprocessor 52 and circuitry 53 and is preferably contained within, attached to, or an element of, LED support 12. It is envisioned that controller 50 be programmed by an external controller 55 and powered through cable R.

[0076] In a preferred embodiment, controller 50 generally comprises circuit board 54 having microprocessor 52 attached to a low voltage power supply, battery, or electrical source 56. Microprocessor 52 is configured through circuitry 53 to selectively activate columns 32 of LED's 30. Transistors Q9 and Q10 are in electronic communication with microprocessor 52, power supply, battery, or electrical source 56, and their respective columns 32.9 and 32.10 of LED's 30. Columns 32 of LED's 30 are connected to transistors Q1-Q8, which are in turn connected to microprocessor 52 through resistors R1-R8. Microprocessor 52 is capable of selectively activating transistors Q1-Q8 to allow current flowing through transistors Q9 and Q-10 to activate the selected column 32 of LED's 30. This circuit is capable of producing a constant light signal, a strobe light

signal, a revolving light signal, a pulsating light signal, an oscillating light signal, or flashing light signal, a reverse character message, or images such as arrows.

[0077] In one embodiment, a rotating or oscillating light signal is preferably established by the sequential illumination of entire columns 32 of LED's 30 turning a desired number of columns on and then sequentially illuminating one additional column 32 while turning another column 32 off. Alternatively, the rotating or oscillating light signal may be created by selectively activating columns 32 of LED's 30. The following algorithm may be used to provide a counterclockwise revolving light signal (FIG. 9):

- 1) column A is activated at 0% duty cycle (column A 0%), column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 2) column A 25%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 3) column A 50%, column B 25%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 4) column A 75%, column B 50%, column C 25%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 5) column A 100%, column B 75%, column C 50%, column D 25%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 6) column A 100%, column B 100%, column C 75%, column D 50%, column E 25%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 7) column A 75%, column B 100%, column C 100%, column D 75%, column E 50%, column F 25%, column G 0%, column H 0%, column I 0%, and column J 0%;
- 8) column A 50%, column B 75%, column C 100%, column D 100%, column E 75%, column F 50%, column G 25%, column H 0%, column I 0%, and column J 0%;
- 9) column A 25%, column B 50%, column C 75%, column D 100%, column E 100%, column F 75%, column G 50%, column H 25%, column I 0%, and column J 0%;

10) column A 0%, column B 25%, column C 50%, column D 75%, column E 100%, column F 100%, column G 75%, column H 50%, column I 25%, and column J 0%;

11) column A 0%, column B 0%, column C 25%, column D 50%, column E 75%, column F 100%, column G 100%, column H 75%, column I 50%, and column J 25%;

12) column A 0%, column B 0%, column C 0%, column D 25%, column E 50%, column F 75%, column G 100%, column H 100%, column I 75%, and column J 50%;

13) column A 0%, column B 0%, column C 0%, column D 0%, column E 25%, column F 50%, column G 75%, column H 100%, column I 100%, and column J 75%;

14) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 25%, column G 50%, column H 75%, column I 100%, and column J 100%;

15) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 25%, column H 50%, column I 75%, and column J 100%;

16) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 25%, column I 50%, and column J 75%;

17) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 25%, and column J 50%;

18) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 25%;

19) column A 0%, column B 0%, column C 0%, column D 0%, column E 0%, column F 0%, column G 0%, column H 0%, column I 0%, and column J 0%;

20) return to step 1).

[0078] A clockwise revolving light signal is created by performing steps 1-19 in descending order then repeating the steps. An oscillating light signal is created by performing: (a) steps 7 through 16 in ascending order; (b) steps 7 through 16 in descending order; and (c) repeating (a) and (b).

[0079] A second embodiment of controller 50 provides a means for activating LED's 30 individually to

allow for greater flexibility in the type of light signal created. This embodiment of the invention is capable of displaying information in different colors or patterns. Depending on the size of the display, it may be necessary to scroll the symbols or characters across the display to accommodate for a larger visual appearance. It is envisioned that the mirror image of patterns, symbols, or characters could be displayed making the message easily readable by drivers viewing the signal in a rear view mirror. It is also envisioned that this embodiment of the invention could display arrows indicating a direction a vehicle is to travel or other images as shown in FIG. 2. In addition, combinations of signaling lights, direction arrows, and other information carrying signals or images, could be displayed simultaneously by the invention.

[0080] LED support 12 is envisioned to have several embodiments. One embodiment, shown in FIG. 9, consists of a panel 14 having front 16, back 18, top 20, bottom 22 and sides 24. LED's 30 are arranged on front 16, with domes 36 extending therefrom, in columns 32 and rows 34. LED's 30 are in electric communication with controller 50 which may be contained or sealed within LED support 12 to provide protection from the elements.

[0081] Another embodiment of warning signal light 10 is depicted in FIG. 10. Here, the backs 18 of two panels 14 are attached together to allow for a light signal to be produced on two sides. The two panels form LED support 12. Alternatively, it is envisioned that a single panel 14 having LED's arranged about front 16 and back 18 could be used as well.

[0082] FIGS. 6 and 8 show further embodiments of warning signal light 10. In FIG. 8, panels 14 are used to form an LED support 12 having four sides and generally shaped as squared. FIG. 6 shows panels 14 connected to form an LED support 12 having three sides and generally shaped as a triangulated cylinder. In both embodiments, LED's 30 are arranged about the fronts 16 of the panels 14. It is further envisioned that panels 14 may be integral to each other.

[0083] Yet another embodiment of warning signal light 10, consists of a flexible panel 14 and controller 50 to allow LED support 12 to be formed into various shapes. FIG. 5 shows LED support 12 formed into a circular cylinder. Further variations include the use of flexible panels 14 to form other shapes such as semicircles (FIG. 12) or to simply conform to a surface of an emergency vehicle (FIGS. 13 and 14). This embodiment is particularly useful for undercover vehicles which generally position the warning signal lights inside the vehicle. For example, panel 14 could be attached to the front, rear, or side window of an undercover police car.

[0084] It should be noted that numerous other shapes could be formed from panels 14 including those formed from combinations of flat, curved, and flexible panels at the preference of an individual.

[0085] In each of the embodiments discussed

above, the array of LED's 30 may comprise the same or differently colored LED's. Generally, each column may consist of a series of differently colored LED's. Controller 50 may be configured to select the color LED to utilize in forming the light signal. Accordingly, the user may select that a blue, red, white, yellow, green, amber, or combination thereof be used as the color of light signal. Alternatively, the warning signal 10 may be formed of individual LED's 30 which may be selectively illuminated at the discretion of an individual.

[0086] It is also envisioned that the controller 50 may control warning signal lights 10 having multiple sides (FIGS. 5, 6, 8, and 10) such that each side is capable of producing light signals that are independent and/or different from those produced by the other sides. For example, the squared cylinder warning signal light shown in FIG. 8 may produce or simulate a red revolving light on first side 15.1, while second side 15.2 is simultaneously producing a blue oscillating light, while third side 15.3 is producing or simulating a stationary white light, and while fourth side 15.4 is producing a white strobe light.

[0087] Another embodiment of warning signal light 10 is depicted in FIGS. 1 and 2 as light bar 70 which extends from driver side 100 to passenger side 102 of emergency vehicle 104. Cover 82 protects light bar 70 from the elements. Each side of light bar 70 may have LED's 30 to produce or simulate light signals on each side of emergency vehicle 104. Furthermore, controller 50 is used to create multiple light signals on each side of light bar 70. For example, controller 50 may create a simulated revolving blue light positioned at front passenger side 102 of light bar 70, oscillating white lights positioned at front driver side 100, and yellow arrows there between. Additional or alternative light signals may be produced out the back 18 and sides of light bar 70. It is further envisioned that light bar 70 may consist of a single large array of LED's 30 across each side (not shown). This embodiment provides the largest display and, therefore, is best suited to display desired combinations of warning lights and images.

[0088] Mechanical rotation and oscillation of warning signal lights 10 about axis A is possible by way of attachment to gyrator 90 depicted in FIG. 3. Gyrator 90 mounted to light bar 70, generally comprises electric motors 96 having cables 97. Gyrator 90 is configured to receive connecting portion 40 of warning signal light 10. Cable 97 is preferably connected to a power supply and either an external controller 55 or controller 50.

[0089] Gyrator 90 may be capable of rotating or oscillating warning signal light 10 about a single or dual axis of rotation A. FIG. 3 shows gyrator 90 configured to rotate or oscillate warning signal light 10 about a vertical axis A by way of motor 96.1 and oscillate warning signal light 10 about a horizontal axis A by way of motor 96.2. Rotation or oscillation of warning signal light 10 about vertical axis A is accomplished through direct attachment of connecting portion to motor 96.1. Oscillation of

warning signal light 10 about horizontal axis A is accomplished by attaching swivel arm 99 to bracket 99.1 and post 99.2 which is mounted to motor 96.2.

[0090] Alternative methods for imparting rotation or oscillation of warning signal light 10 may be accomplished through the use of electric motors, toothed gears, and worm gears. In addition, maintaining electrical communication between a power supply and an external controller 55 with a revolving or oscillating warning signal light 10 may be accomplished using brushes or other means without sacrificing the operation of the warning signal light 10.

[0091] In another embodiment as depicted in FIGS. 13 and 14, emergency vehicle 104 may include a front or rear windshield 106. The front or rear windshield 106 is generally angularly offset with respect to the vehicle at an approximate angle of 45 degrees. In this embodiment, the mounting of a panel 14 of light sources 30 in flush contact with the interior of a front or rear windshield 106 occurs through the use of angular offsets 108 for the light sources 30 such that light emitted from the light sources 30 occur at a horizontal visual line (V) which is substantially parallel to the plane of a vehicle and not at an approximate angle of 45 degrees upward which corresponds to the angle for the front or rear windshield 106.

[0092] In this embodiment, the ease of visualization of the light source 30 is significantly enhanced by the downward angular offsets 108 which position the light sources 30 along parallel visual lines of sight (V). LED supports 12 or panels 14 may then be positioned in any desired location within the interior of a vehicle in flush contact or proximate to the front or rear windshield 106. A suitable cable 97 is required to provide electrical power for illumination of the light sources 30. It should be noted that the angle of incidence for the angular offsets 108 may vary considerably dependent upon the make or model for the vehicle to include the warning signal lights 10.

[0093] It should be further noted that the warning signal light 10 may be used with an automobile, motorcycle, snowmobile, personal water craft, boat, truck, fire vehicle, helicopter, and/or any other type of vehicle receptive to the use of warning signal lights 10. It should be further noted that LED support 12 or panel 14 may be mounted to the interior top dashboard of a vehicle proximate to the front windshield 106 or to the interior top rear dashboard proximate to the rear windshield 106 of a vehicle.

[0094] Mounting of a light support 12 or panel 14 to either the front or rear dashboards may minimize the necessity for inclusion of angular offset 108 for the light sources 30. It should be further noted that LED supports 12 or panels 14 may be releasably affixed to the interior of the front or rear windshields 106 via the use of suction cups, hook-and-loop fabric material such as Velcro®, and/or any other releasable affixation mechanism at the preference of an individual. An individual

may then adjust and reposition the location of the light support 12 or panels 14 anywhere within the interior of a vehicle as desired for maximization of visualization of the warning signal lights 10.

[0095] In another alternative embodiment as depicted in FIG. 15, warning signal light 10 may function as a remote, revolving, or stationary beacon. In this embodiment, LED support 12 or panel 14 is preferably releasably connected to a transportable support 120 via the use of a bracket. The transportable support 120 may be a tripod having telescoping legs or may be any other type of support as preferred by an individual. In this embodiment, LED support 12 or panel 14 is electrically connected to an elongate electrical extension cable 97 which may include any desired adapter for electrical communication with the electrical system of a vehicle. The remote light support 12 or panel 14 may also include plug-in adapters for electrical connection to any desired electrical power source other than a vehicle as is available.

[0096] The transportable support 120 may also include gyrotator 90 as earlier described to provide a desired rotational or oscillatory motion for warning signal light 10. A controller 50 having a microprocessor 52 may also be integral to or in electrical communication with LED's 30 for the provision of multi-colored lights, flashing, or moving characters as desired by an individual. In this embodiment, the warning signal light 10 may be physically separated from an emergency vehicle 104 any desired distance to facilitate or enhance the safety of a potentially dangerous situation necessitating the use of warning signal lights 10. In addition, it should be noted that a series of remote warning signal lights 10 may be electrically coupled to each other for any desired distance to again facilitate the safety of a situation necessitating the use of warning signal lights 10.

[0097] FIG. 16 shows a perspective view of a xenon lamp 1. Xenon lamp 1 has a base pedestal 2 which is typically formed of rubber, plastic, or other insulating material. Base pedestal 2 has a top surface 3 which may support a glass tube 4 which may have a looped curve such that an anode end and a cathode end are each supported on a top surface. The anode and cathode ends may be sealed and respective electrical conductors 5 and 6 may pass through the sealed ends and through the top surface 3. A trigger wire 7 may be helically wound about the exterior surface of the glass tube 4 and the ends of the trigger wire 7 may be passed through the top surface 3 of the base pedestal 2 to form a third conductor on the underside of the base pedestal 2.

[0098] Base pedestal 2 may have an upper cylinder portion 8 extending from a lower shoulder all of which may extend above the top surface 3. The upper cylindrical portion 8 may include an upper shoulder 9. A glass dome (not shown) may be sized to fit over the xenon lamp 1 and glass tube 4 for resting on the upper shoulder 9. The glass dome may be preferably made from a

transparent or silicate glass material capable of withstanding heat stress. The outer diameter of the glass dome is typically about one inch which is sized to fit through the conventional opening in a typical vehicle lamp fixture. The exterior glass dome surface typically has a much lower temperature during operation than the exterior surface of the glass tube 4 forming a part of the xenon lamp 1. The temperature drop between the glass tube 4 and the glass dome facilitates the use of coloring of the dome to provide a colored lamp by virtue of the xenon light intensity passing through the colored dome.

[0099] The xenon lamp 1 is preferably aligned for insertion into a conventional opening 248 of a light reflector 260 (FIGS. 20 and 21). The light receptacle opening 248 in the light reflector 260 is typically about one inch in diameter; and the glass dome and base pedestal 2 are preferably sized to fit within the light receptacle opening 248. The xenon lamp 1 in its final construction may include a cover plate (not shown) affixed over the bottom opening of the base pedestal 2 for affixation to a light reflector 260 via the use of screws which pass through the screw apertures 9.1. The anode, cathode, and trigger wire 7 preferably traverse the base pedestal 2 and may include a plug 9.2 which is adapted for engagement to a controller/power supply for a motor vehicle.

[0100] The light reflector 260 may be a conventional light reflector of the type found in vehicles having a clear plastic or glass lens cover. The glass or lens cover may be fitted over the front edge of the reflector 260 in a manner which is conventional with vehicle lamps. It should be noted that the light reflector 260 may be parabolically or other shaped at the preference of an individual. The light reflector 260 may be mounted to a motor for rotation about a vertical axis. In this embodiment the light source/replacement lamp 200 may be integrally connected or affixed to the reflector 260 for simultaneous rotation about the vertical axis during use of the motor. Alternatively, the light source/replacement lamp 200 may be fixed proximate to the vertical axis where the light reflector 260 is rotated around the stationary replacement lamp 200 to provide for the visual appearance of a rotational light source.

[0101] The glass domes as used with the xenon lamps 1 may be colored with any color as preferred by an individual including but not limited to red, blue, amber, green, and/or white. It should be noted that the light fixture incorporating the light reflector 260 may be a headlight fixture or a turn signal light fixture where the xenon lamp 1 is mounted into the light reflector 260 on either side of a centrally-mounted halogen light bulb which may be used as a headlight lamp. In this case, the light fixture could perform its normal function as a headlight and could alternatively flash several additional colors, depending upon the needs of the user. This configuration provides an emergency flashing light construction which is wholly concealed within a normal

head lamp of a vehicle and is, therefore, not readily visible from outside the vehicle unless the lights are flashing. This construction may find application in an unmarked emergency vehicles such as might be used by some law enforcement officers.

[0102] In operation, the LED replacement lamp 200 may be constructed as a replacement part for a conventional incandescent or xenon gaseous discharge lamp. The standard mounting base 204 and LED support assembly 212 may be sized to readily fit into the same light opening as an incandescent lamp would require; although it is apparent the electrical driving circuit for the xenon lamp 1 may require modifications to accommodate the gas discharge operating principles.

[0103] LED warning signal lamp 200 may be used in a variety of locations about a vehicle. It should be noted that the use of the LED warning signal lamps 200 are not necessarily limited to positioning adjacent to the head lamp or headlight, tail light, or turn signal illumination devices for an emergency vehicle 104. The LED warning signal lamp 200 may be used as a rotational, pulsating, or oscillating reflector light within the interior adjacent to a front, rear, and/or side window of a vehicle.

[0104] It is also envisioned that the controller 50 may control warning signal lights 200 independently of one another such that each warning signal lamp 200 is capable of producing light signals which are independent and/or different from those produced at another location about an emergency vehicle 104. For example, a front left turn signal may produce a red colored light while simultaneously a front right turn signal may produce an amber colored light and a right rear turn signal may produce a green colored light and a left rear turn signal may produce a blue colored light. The controller 50 may then alternate the color of the light illuminated from the warning signal lamp 200 in each area as desired by an individual. Alternatively, the controller 50 may sequentially activate warning signal lamps 200 positioned about an emergency vehicle 104 to simultaneously produce a desired color or alternating sequence of colors. It should also be noted that the controller 50 may simultaneously illuminate all LED warning signal lamps 200 to produce a flashing or strobe light which may be particularly useful in certain emergency situations. It should be further noted that the controller 50 may selectively illuminate individual LED warning signal lamps 200 in any desired color, pattern, and/or combination as desired by an individual.

[0105] Referring to FIG. 17 in detail, an LED replacement lamp 200 is depicted. In this embodiment the LED replacement lamp 200 includes a standard mounting base 204 which preferably includes a top surface 206. Extending upwardly from the top surface 206 is preferably an upper cylindrical portion 208 which includes an upper shoulder 210. Extending upwardly from the upper shoulder 210 is preferably a support 212 which includes one or more LED lamp modules 213. The LED lamp modules 213 may be of the same or dif-

ferent colors at the discretion of an individual. A wire 202 is preferably in electrical communication with the plurality of LED lamp modules 213 to provide the electrical communication and contact for the controller 50 to individually activate or illuminate LED lamp modules 213 as preferred by an individual. A plug-in connector 40 is preferably coupled to the wire 202 for engagement to the controller 50 and/or power source of an emergency vehicle 104.

[0106] The LED replacement lamp 200 is preferably adapted to be positioned in a one inch light receptacle opening 248 (approximate size) which has been previously drilled into the backside of a reflector assembly 260. The LED replacement lamp 200 is preferably used to replace a xenon gaseous discharge lamp or incandescent lamp as previously mounted to a base and as inserted in opening 248 in a reflector assembly 260. Illumination of one or more individual LED lamp modules 213, as mounted in the reflector assembly 260, enables the reflector assembly/lens to take on the appearance of a warning signal or emergency signaling lamp. The LED replacement lamp 200 preferably replaces the xenon gaseous discharge or incandescent lamp assemblies with high brightness, long life LED technology.

[0107] Referring to FIG. 18, an incandescent lamp or quartz halogen H-2 lamp is depicted and in general is indicated by the numeral 220. The incandescent lamp assembly 220 is preferably formed of a standard mounting base 222. A vertical post 224 preferably extends upwardly from the standard mounting base 222. The incandescent light bulb 226 is preferably mounted in the vertical post 224. The vertical post 224 may extend below the standard mounting base 222 to provide for electrical coupling with a wire 228 which preferably includes a standard pin connector 230. The standard pin connector 230 is preferably adapted for electrical communication to a power supply and/or controller 50 for activation of the incandescent lamp assembly 220. The incandescent lamp assembly 220 may be stationary or mounted in a rotational light reflector 260 as desired by an individual. The light bulb 226 may be a halogen H-2, 55 watt, lamp at the discretion of an individual.

[0108] As depicted in FIG. 19, LED replacement lamp 200 is adapted to replace the incandescent lamp assembly 220 in a stationary or rotational light reflector 260. The LED replacement lamp 200 as depicted in FIG. 19 preferably includes a standard mounting base 234 and a vertical post 236. It should be noted that the vertical post 236 may extend upwardly from the standard mounting base 234 and may alternatively extend below the standard mounting base 234 at the preference of an individual. An LED mounting area 238 may be preferably integral or affixed to the upper section of the vertical post 236. The LED mounting area 238 preferably includes a plurality of individual LED module lamps 240 which may be individually, sequentially, or illuminated in combination with other light sources at the

preference of an individual.

[0109] The individual LED module lamps 240 are preferably in electrical communication with a wire 242 which includes an integral standard wire connector 244. The wire connector 244 is preferably adapted to be plugged into a controller 50 or power supply. Communication is thereby provided for selective illumination of the individual LED module lamps 240. It should be noted that a group of individual LED module lamps 240 are mounted in the LED mounting area 238. It should also be noted that the LED replacement lamp 200 is preferably adapted to replace the incandescent lamp assembly 220 or a xenon gaseous discharge lamp assembly socket base of FIGS. 16 or 18. The purpose of the LED replacement lamp assembly 200 is to replace existing xenon gaseous discharge and incandescent lamps with new LED technology while simultaneously utilizing existing standard bases in a standard lamp enclosure. For example, an individual may choose to replace a halogen "H-2" 55 watt lamp with an "LED-2" lamp in an existing rotating light fixture with no other structural modifications, yet achieving the advantages of less power consumption, greater reliability, easier installation, less RF emissions (which reduces interference with radio or electronic equipment), cooler operating temperatures, simplified circuitry, longer life, greater durability and duty capability, and simultaneously providing pure and easier-to-see color light output.

[0110] As depicted in FIG. 20, a rotational light reflector 246 is disclosed. The rotational light fixture 246 includes a reflector assembly 260 having a standard opening 248. The incandescent light assembly 220 is preferably positioned in the standard opening 248 for extension of the vertical post 224 outwardly from the reflector assembly 260 for positioning of the light bulb 226 in a desired location. Light emitted from the standard halogen light bulb 226 preferably reflects off the parabolic-shaped reflector assembly 260 for transmission of light in a direction as indicated by arrows AA for visualization by individuals. Reflector assembly 260 and light source 226 may be rotated via the use of gears 250 and/or brushes which are preferably driven by electrical motors not shown. In this manner, the rotational light fixture 246 including the reflector assembly 260 may be rotated at any desired velocity as preferred by an individual.

[0111] As may be seen in FIG. 21, a rear or back view of the rotational light fixture 246 is provided. As may be seen in FIG. 21, the light source is preferably positioned in the standard opening 248. The wire 228 as in electrical communication with the light source and is preferably connected via the standard pin connector 230 for electrical communication with a power source.

[0112] As depicted in FIG. 22, an alternative rotational light fixture 252 is depicted. Rotational light fixture 252 preferably includes a reflector assembly 260 which may be parabolic in shape for the transmission of light along a common axis as depicted by arrows BB for vis-

ualization by an individual. In this embodiment, the individual LED module lamps 240 may be positioned to the front of the reflector assembly 260 through the use of a frame 254. The frame 254 may be integral or connected to a gear 250 as desired by an individual. The gear 250 may be driven by a motor for rotation of the light fixture 252. It should be noted that the individual LED module lamps 240 are preferably in electrical communication with a power source not shown.

[0113] It should be further noted that the rotational light fixture 252 may also be adapted for oscillating or pulsating at the preference of an individual.

[0114] An alternative replacement LED lamp 200 is depicted in FIGS. 23-25. In this embodiment the LED replacement lamp 200 includes a standard mounting base 270. The standard mounting base 270 also preferably includes a plurality of teeth 272. The teeth 272 are preferably adapted for mating coupling with gears integral to a motor and/or reflector 260, or rotational light fixture 246 to facilitate rotation and/or oscillation of the replacement LED lamp 200 at the discretion of an individual. The standard mounting base 270 also preferably includes a top surface 274 opposite to the teeth 272.

[0115] An upper cylinder portion 276 is preferably adjacent to the top surface 274. The upper cylindrical portion 276 preferably includes an upper shoulder 278. Extending upwardly from the upper shoulder 278 is preferably a circuit board or support 280 which preferably includes one or more LED illumination sources 282. The LED illumination sources 282 may be of the same or different colors at the preference of an individual. A wire 284 is preferably in electrical communication with the LED illumination sources 282 to provide for communication and contact with the controller 50 for combination and/or individual illumination of the LED illumination sources 282. A standard plug-in connector may be integral to the wire 284 to facilitate coupling engagement to the controller 50 and/or power source for a vehicle 104.

[0116] The circuit board 280 is preferably adapted to have a first side 286 and an opposite side 288. Preferably a plurality of LED illumination sources 282 are disposed on both the first side 286 and the opposite side 288 of the replacement lamp 200.

[0117] A glass dome or protector 290 is preferably adapted for positioning over the circuit board 280 for sealing engagement to the top surface 274 of the standard mounting base 270. The glass dome 290 may be formed of transparent plastic material or a transparent or silicate glass material capable of withstanding heat stress at the preference of an individual. It should be further noted that the glass dome 290 preferably protects the circuit board 280 and the LED illumination sources 282 from contamination and from exposure to moisture during use of the replacement lamp 200. In this regard, the sealing lip 292 of the glass dome 290 preferably is securely affixed to the top surface 274 to effectuate sealing engagement therebetween. The outer diameter of the glass dome 290 is preferably about one inch

which is sized to fit within the conventional opening 248 in a typical lamp fixture or reflector assembly 260.

[0118] The replacement lamp 200 depicted in FIGS. 23, 24, and 25 is also adapted to be positioned in a one inch light receptacle opening 248 which has been placed into a reflector assembly 260. Illumination of one or more individual LED illumination sources 282 as disposed on the circuit board 280 enables the replacement lamp 200 to take on the appearance of a warning signal or emergency signaling lamp.

[0119] The replacement lamp as depicted in FIGS. 23, 24, and 25 may alternatively permit the circuit board 280 to extend below the upper shoulder 278 to facilitate affixation and positioning relative to the standard mounting base 270.

[0120] The controller 50 may regulate the illumination of the LED light sources 282 individually, or in combination, to provide a desired lighting effect for the replacement lamp 200. Also, the controller 50 may illuminate the LED light sources 282 individually, or in combination, independently with respect to the first side 286 and the opposite side 288 to provide different light effects to be observed by an individual dependant upon the location of the person relative to the replacement lamp 200. The controller 50 may also regulate the power intensity to the LED illumination sources 282 to provide for a modulated or variable light intensity for observation by an individual. It should also be noted that the LED illumination sources 282 may be formed of the same or different colors at the preference of an individual to provide a desired type of light effect for the replacement lamp 200.

[0121] In an alternative embodiment, the LED warning signal lamps 10 or LED replacement lamps 200 may be electrically coupled to a controller 50 which in turn is used to provide a modulated power intensity for the light source. A modulated power intensity enables the provision of various patterns of illumination to create an illusion of rotation or pulsation for the warning signal lamps 10 or LED replacement lamps 200 without the use of mechanical devices. In these embodiments, the controller 50 regulates and/or modulates the power supplied to the warning signal lamps 10 or LED replacement lamps 200 thereby varying the intensity of the observed light. In addition, the controller 50 may modulate the power supplied to the LED warning signal lamps 10 or LED replacement lamps 200 in accordance with a sine wave pattern having a range of 0 to full intensity. At the instant of full intensity, the controller 50 may also signal or regulate a power burst for observation by an individual. The controller 50 operating to regulate and/or modulate the power intensity for the warning signal lamps 10 or LED replacement lamps 200 may establish the appearance of a rotational light source or pulsating light source without the necessity of mechanical rotational or oscillating devices. The current draw upon the electrical system for an emergency vehicle 104 is thereby reduced. Spatial and size considerations for an emergency vehicle are

also preferably optimized by elimination of mechanical, rotational and/or oscillation devices.

[0122] The controller 50 may also regulate the modulated power intensity for the provision of a unique variable intensity light source. The unique variable intensity light source is not required to cycle through a zero intensity phase. It is anticipated that in this embodiment that the range of intensity will cycle from any desired level between zero power to full power as desired by an individual. A range of power intensity may be provided between thirty percent to full power and back to thirty percent as regulated by the controller 50. It should be further noted that an irregular pattern of power intensity may be utilized to create a desired type of light effect. In addition, the controller 50 may also sequentially illuminate adjacent columns 32 to provide a unique variable rotational, oscillating, pulsating, and/or combination variable rotational pulsating oscillating visual light effect. It should be noted that a pulsating light source may be provided through the use of a modulated power intensity to establish a varying visual illumination or intensity effect as desired by an individual without the use of rotational or oscillating devices. In this regard it should be noted that the controller 50 may modulate the power intensity for any combination of light sources 30 to provide a distinctive type of light signal.

[0123] The use of a controller 50 to provide a modulated power intensity for a light source may be used in conjunction with replacement lamps 200, flexible circuit boards having LED light sources 30, paneled circuit boards having LED light sources 30, light bars 70 having LED light sources 30, a cylindrical, square, rectangular, or triangular-shaped circuit boards having LED light sources 30 and/or any other type or shape of LED light sources including but not limited to the types depicted in FIGS. 1-25 herein.

[0124] Further, the controller 50 may be utilized to simultaneously provide modulated or variable light intensity to different and/or independent sections, areas, and/or sectors of a light bar 70. Also, the controller 50 may be utilized to simultaneously provide modulated or variable light intensity to different and/or independent sectors, areas, and/or sections of the forward facing side or rearward facing side of the light bar 70. In this embodiment it is not required that the forward facing and rearward facing sides of the light bar 70 emit the identical visual patterns of illuminated light sources 30. The controller 50 may regulate and modulate the variable light intensity of any desired section of the forward facing side independently from the rearward facing side of the light bar 70. The controller 50 may thereby provide any desired pattern and/or combination of patterns of light signals through the utilization of variable and/or modulated light intensity for the forward facing side, and a different type or set of patterns and/or combination of patterns of light signals having variable or modulated light intensity for the rearward facing side of the light bar 70 as desired by an individual. It should be

further noted that an infinite variety of patterns and/or combinations of patterns may be provided for the forward facing side and the rearward facing side of the light bar 70 at the preference of an individual.

[0125] The use of the controller 50 to modulate the power intensity for a light source 30 to provide a unique light signal may be utilized within any embodiment of an LED light source 10, light bar 70, or replacement lamp 200 as described herein.

[0126] It should be further noted that the modulation of the power intensity for a light source 30 or replacement lamp 200 may be used in conjunction, or as a replacement of, the sequential illumination of rows, columns, and/or individual LED light sources 30 to provide a desired type of unique light effect.

[0127] A modulated power intensity may be regulated by the controller 50 to create a unique light signal within a single sector or in conjunction with multiple separated or adjacent sectors of light bar 70 for the provision of any desired composite emergency light signal as preferred by an individual. All individual LED light sources 30 within a light bar 70 may be exposed to incrementally increased modulated power intensity to provide for an incremental increase in illumination as regulated by a controller 50. The incremental increase in power may continue until such time as maximum power is applied to an individual light source 30 whereon a power burst may occur. The modulation of the power intensity for the incremental increase in illumination of all LED light sources 30 within light bar 70 thereby may provide the appearance of rotation of a light signal when observed by an individual. The power to the individual light sources 30 may then be incrementally decreased at the preference of an individual. It should be noted that the power is not required to be regularly incrementally increased or decreased or terminated. It is anticipated that a pulsating and/or modulated variable light intensity may be provided by the controller 50 for regulation of the power output from approximately thirty percent to maximum and back to thirty percent which affords a desirable type of pulsating modulated variable light effect.

[0128] It should also be noted that all individual LED light sources 30 within a light bar 70 are not required to be simultaneously and incrementally illuminated to provide for the appearance of rotation. For example, a light bar 70 may be separated into one or more distinct segments 76 which are formed of one or more columns 32 of LED light sources 30. A particular segment 70 may be selected as a central illumination band which may receive the greatest exposure to the modulated power source and, therefore, provide the brightest observable light signal. An adjacent segment 78 may be disposed on each side of the central illumination band which in turn may receive modulated power of reduced intensity as compared to the central illumination band. A pair of removed segments 80 may be adjacent and exterior to the segments 78, and in turn, may receive exposure to

a modulated power source of reduced intensity as compared to segments 78. The number of desired segments may naturally vary at the discretion of an individual. The controller 50 may thereby regulate a power source to provide a modulated or variable power intensity to each individual segment 76, 78, or 80 to provide for a unique light effect for the light bar 70.

[0129] It should be further noted that light supports 12 may be flat and rigid, pliable, moldable, triangular, cylindrical, partially cylindrical, and/or any other shape as desired by an individual provided that the essential functions, features, and attributes described herein are not sacrificed.

[0130] The provision of a modulated power intensity to the light bar 70 may also be coupled with or in combination to the sequential illumination of columns 32 as earlier described. In this situation, the light signal may initially be dim or off as the individual columns 32 are sequentially illuminated and extinguished for illumination of an adjacent column or columns 32. The power intensity for the illuminated column or columns 32 may simultaneously be incrementally increased for a combination unique rotational and pulsating modulated or variable light signal effect. In addition, the controller 50 may be programmed to provide the appearance of rotation pulsation and/or oscillation at the discretion of an individual.

[0131] Each individual LED light source 30 preferably provides an energy light output of between 20 and 200 or more lumens as desired by an individual.

[0132] Each light support 12 preferably contains a plurality of rows 34 and columns 32 of individual LED light sources 30. The supports 12 are preferably in electrical communication with the controller 50 and power supply. The supports 12 preferably are controlled individually to create a desired light signal for an emergency vehicle 104 such as rotation, oscillation, strobe, flashing, or stationary as preferred by an individual. Each support 12 may be controlled as part of an overall light signal or pattern where individual supports 12 may be illuminated to provide a desired type or combination of light signal in addition to the provision of a modulated or variable power intensity for the light source 30.

[0133] A modulated power intensity may be regulated by the controller 50 to create the appearance of rotation within a single support 12 or in conjunction with multiple separated or adjacent supports 12 for the provision of a composite emergency light signal as desired by an individual. The light signal for each or a group of supports 12 may be regulated by the controller for the provision of a modulated power intensity for an observable light signal. All individual LED light sources 30 within a support 12 may be exposed to incrementally increased modulated or variable power intensity to provide for an incremental increase in illumination as regulated by a controller 50. The incremental increase in power may continue until such time as maximum power is applied to an individual light source 30 whereon a

power burst may occur. The modulation of the power intensity for the incremental increase in illumination of all LED light sources 30 within supports 12 thereby may provide a desired visual light signal for observation by an individual.

[0134] It should also be noted that the LED warning signal lamps 200 may be incorporated into a light bar 70 which extends from a position proximate to the driver's side 100 to a position proximate to the passenger side 102 of an emergency vehicle 104. Cover 82 protects light bar 70 from the elements. Each of the forward facing and rearward facing sides of light bar 70 may have LED's 30 to produce light signals on each side of light bar 70. Furthermore, controller 50 is used to create multiple light signals on each of the forward facing and rearward facing sides of light bar 70. For example, a controller 50 may create a blue light signal positioned on the forward facing passenger side 102 of light bar 70, oscillating white lights positioned at the forward facing driver's side 100, and yellow lights there between. Additional light signals may be produced from the rearward facing side of light bar 70 at the discretion of an individual where these light signals are the same as or different from the signals emitted from the forward side 100.

[0135] Mechanical rotation and oscillation of replacement lamps 200 about axis A is possible by way of attachment to gyrator 90 depicted in FIG. 3. Gyrator 90 mounted to a replacement lamp 200 generally comprises electric motors 96 having cables 97. Gyrator 90 is configured to receive connecting portion 40 of replacement lamp 200. Connecting portion 40 preferably includes a integral wire 202 to provide power for illumination of individual LED's 30. Cable 97 connects to a power supply and either an external 55 or internal controller 50 at the discretion of an individual.

[0136] Gyrator 90 may be capable of rotating or oscillating replacement lamps 200 about a single or dual axis of rotation A. FIG. 3 shows gyrator 90 configured to rotate replacement lamps 200 about a vertical axis A by way of motor 96.1 and oscillate replacement lamps 200 about a horizontal axis A by way of motor 96.2. Rotation or oscillation of replacement lamps 200 about vertical axis A is accomplished through direct attachment of a connecting portion to motor 96.1. Oscillation of replacement lamp 200 about horizontal axis A is accomplished by attaching swivel arm 99 to bracket 99.1 and post 99.2 which are mounted to motor 96.2.

[0137] Alternative methods of imparting rotation or oscillation to replacement lamps 200 may be accomplished through the use of electric motors, tooth gears, and/or worm gears at the discretion of an individual.

[0138] It should be noted that each portion, section, sector, or area of light bar 70 may be controlled as part of an overall light signal or pattern where individual sections or sectors may be illuminated to provide a desired type of light signal including but not limited to rotation and/or oscillation through the use of a modulated or variable power intensity. Alternatively, the controller 50 may

provide for the random generation of light signals without the use of a preset pattern at the preference of an individual.

[0139] Controller 50 may be used to selectively activate individual LED's 30 to create a constant light signal, a strobe light signal, a flashing light signal, an alternating light signal, and/or an alternating colored flashing light signal for an emergency vehicle.

[0140] Controller 50 provides a means for activating LED's 30 individually to allow for greater flexibility in the type of light signal created. This embodiment to the invention is capable of displaying information in a variety of different colors or sequential illumination of colors.

[0141] The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof; and it is, therefore, desired that the present embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

Claims

1. A warning signal light comprising:
 - a) a light support having a front side;
 - b) a plurality of light emitting diode (LED) light sources disposed on the front side;
 - c) a controller in electric communication with the light sources, the controller for selectively illuminating the light sources to create a light signal, the controller adapted to vary power intensity provided to the illuminated light sources.
2. The warning signal light of claim 1, wherein said light support is flexible and can be formed into various shapes.
3. The warning signal light of claim 1, said light support further comprising a back side having a plurality of LED light sources disposed thereon.
4. The warning signal light of claim 3, said plurality of light sources comprising LED's of at least two different colors.
5. The warning signal light of claim 4, wherein the light signal is a revolving light.
6. The warning signal light of claim 4, wherein the light signal is an oscillating light.
7. The warning signal light of claim 4, wherein the light signal is a flashing light.
8. The warning signal light of claim 4, wherein the controller is a microprocessor.
9. The warning signal light of claim 4, the light support further comprising a gyrator for moving the warning signal light.
10. A warning signal light comprising:
 - a) a cylindrical body portion having an exterior surface;
 - b) a plurality of light emitting diodes (LED's) arranged about the exterior surface; and
 - c) a controller for selectively illuminating the LED's, the controller adapted to vary power intensity provided to the illuminated LED's.
11. A warning signal light in combination with an emergency vehicle light bar, the warning signal light comprising:
 - a) support having a front;
 - b) a plurality of light emitting diodes (LED's) disposed on the front; and
 - c) a controller in electric communication with the LED's, the controller for selectively illuminating the LED's to create a light signal, the controller adapted to vary power intensity provided to the illuminated LED's.
12. The combination of claim 11, said LED support further comprising a back opposite the front, the back having a plurality of LED's disposed thereon, the controller configured to selectively illuminate the LED's of the back, the controller adapted to vary power intensity provided to the illuminated LED's of the back.
13. A warning signal light for use with an emergency vehicle, the warning signal light comprising:
 - a) a light support mounted to the emergency vehicle, the light support having a plurality of sides;
 - b) a plurality of light emitting diodes (LED's) disposed about at least one of the sides of each light support; and
 - c) a controller in electric communication with the LED's, the controller for selectively illuminating the LED's to create a light signal, the controller adapted to vary power intensity provided to the illuminated LED's.
14. The warning signal light of claim 13, wherein the controller selectively illuminates the LED's to create multiple different light signals.
15. The warning signal light of claim 14, wherein the LED's are disposed about at least two sides, and

wherein the controller is configured to selectively illuminate the LED's on each side independently of the other sides, whereby different light signals may be created on each of the sides.

16. The warning signal light of claim 15, wherein the controller is configured to selectively illuminate the LED's to create multiple different light signals on each side.

17. A multiple warning signal light for use with an emergency vehicle, the multiple warning signal light comprising:

- a) a light support having a front side with a visible exterior surface;
- b) a plurality of light emitting diodes arranged about the visible exterior surface; and
- c) a controller in electric communication with the light emitting diodes the controller for selectively illuminating the light emitting diodes to create a plurality of visually distinctive warning light signals, the controller adapted to vary power intensity provided to the illuminated LED's.

18. The multiple warning signal light of claim 17, said light support further comprising a back side with a visible exterior surface having a plurality of light emitting diodes arranged about the visible exterior surface of the back side of the light support.

19. The multiple warning signal light of claim 18 said plurality of light emitting diodes comprising light emitting diodes of at least two different colors.

20. The multiple warning signal light of claim 19, wherein the controller selectively illuminates the light emitting diodes to create one of a single colored light signal and a multi-colored light signal.

21. The multiple warning signal light of claim 18, wherein the controller independently controls the light emitting diodes on each side of the visible exterior surfaces for the provision of different light signals on each side of the visible exterior surfaces.

22. The multiple warning signal light system of claim 18, the controller selectively illuminating and simultaneously displaying light emitting diodes to create a plurality of visually distinctive warning light signals.

23. A multiple warning signal light in combination with an emergency vehicle light bar, the vehicle light bar having at least one sector, the warning signal light comprising:

- a) a support having a front with a visible exterior surface;

- b) a plurality of light emitting diodes (LED's) disposed on the visible exterior surface of the front; and

- c) a controller in electric communication with the LED's, the controller for selectively illuminating the LED's to create a plurality of visually distinctive warning light signals within the at least one sector, the controller adapted to vary power intensity provided to the illuminated LED's.

24. The combination of claim 23, said support further comprising a back opposite the front, the back having a plurality of LED's disposed thereon, the controller configured to selectively activate the LED's of the back independently of the front.

25. A multiple warning signal light system, for use with a vehicle, the warning signal light system comprising:

- a) a plurality of light supports, the plurality of light supports mounted to a vehicle, each of the plurality of light supports having at least one visible exterior surface;

- b) one or more light emitting diodes (LED's) disposed about the at least one visible exterior surfaces of each of the plurality of light supports; and

- c) at least one controller in electric communication with the controller adapted to vary power intensity provided to illuminated LED's.

26. The multiple warning signal light system of claim 25, wherein the vehicle is an emergency vehicle.

27. The multiple warning signal light system of claim 25, wherein the vehicle is a utility vehicle.

28. The multiple warning signal light system of claim 25, wherein the LED's are disposed about the visible exterior surfaces, and wherein the controller is configured to selectively illuminate the light emitting diodes on each visible exterior surface of each support independently of the other visible exterior surfaces, whereby different light signals may be created on each of the visible exterior surfaces.

29. A multiple warning signal light system comprising:

- a) a plurality of light supports, each of the plurality of light supports having one or more visible exterior surfaces, the one or more visible exterior surfaces having a plurality of light emitting diodes disposed (LED's) thereon; and
- b) a controller in electric communication with

- each of the plurality of LED's, the controller selectively illuminating the LED's of the one or more visible exterior surfaces to provide each of the one or more visible exterior surfaces with one or more of a plurality of independent and visually distinctive warning light signals, the controller adapted to vary power intensity provided to the illuminated LED's.
30. The multiple warning light system of claim 29 wherein LED's of at least 2 of the plurality of light supports are selectively activated to provide the one or more visible exterior surfaces respectively with a common visually distinctive light signal.
31. The multiple warning signal light system of claim 30 further comprising a vehicle, the one or more light supports mounted to the vehicle.
32. A multiple warning signal light system comprising:
- a) at least one light support, the at least one light support having at least one visible exterior surface, the at least one visible exterior surface having a plurality of light emitting diodes (LED's) disposed thereon; and
 - b) a controller in electric communication with the LED's, the controller selectively illuminating the LED's of the at least one visible exterior surface to provide the at least one visible exterior surface with at least one of a plurality of independent and visually distinctive warning light signals, the controller adapted to vary power intensity provided to the illuminated LED's.
33. The multiple signal warning light system of claim 32 wherein the plurality of independent and visually distinctive warning light signals warn and direct traffic.
34. The multiple signal warning light system of claim 32 each light support comprising one or more sectors, the controller independently regulating each of the sectors with one or more of the plurality of independent and visually distinctive warning light signals.
35. A replacement light emitting diode (LED) lamp module comprising:
- a) a base having an electrical connector having a plug, said base having an approximate diameter dimension of one inch; and
 - b) a support assembly extending from said base, said support assembly having at least one light emitting diode (LED) illumination source.
36. The replacement LED lamp module according to claim 35, said support assembly comprising a plurality of LED illumination sources.
37. The replacement LED lamp module according to claim 35, wherein said LED illumination sources are adapted to provide different colored light signals.
38. The replacement LED lamp module according to claim 36, further comprising a controller to selectively illuminate said LED light sources.
39. The replacement LED lamp module according to claim 38, wherein said controller is adapted to vary power exposed to said LED illumination sources to provide variable light intensity to said LED illumination sources.
40. The replacement LED lamp module according to claim 39, wherein said LED lamp module is positioned within an opening in a vehicle having an approximate diameter dimension of one inch.
41. The replacement LED lamp module according to claim 39, further comprising a reflector, said LED lamp module being connected to said reflector.
42. The replacement LED lamp module according to claim 41, said reflector comprising a rotational base, said rotational base adapted for the provision of rotational motion to said reflector and to said LED lamp module.

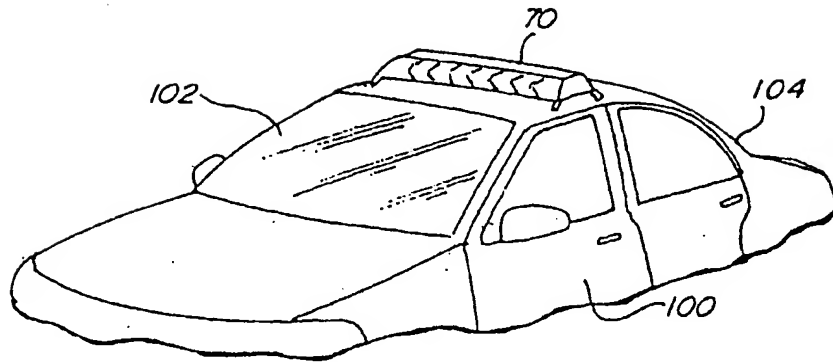


Fig. 1.

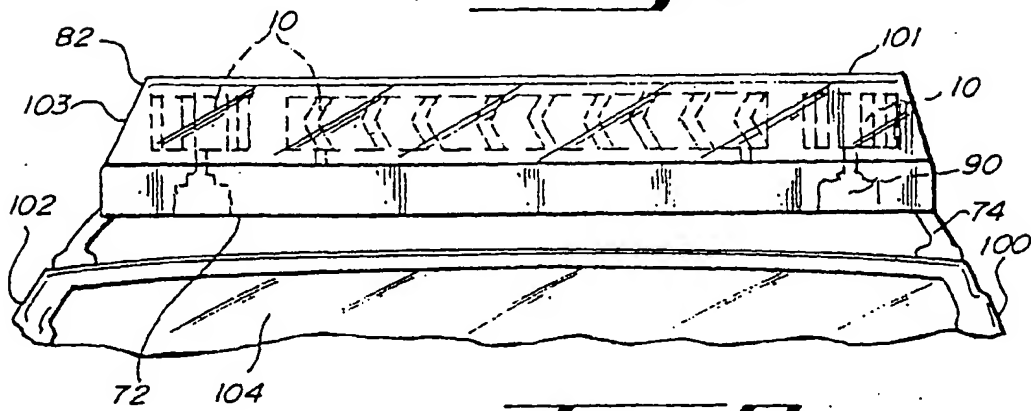


Fig. 2.

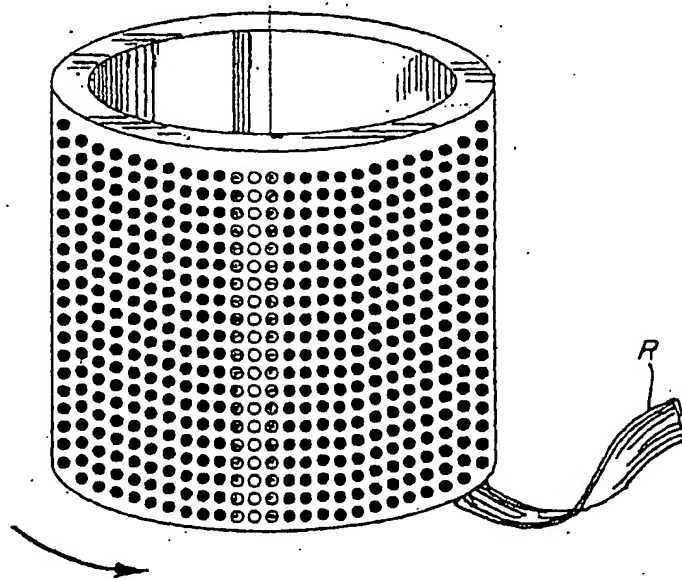


Fig. 4.

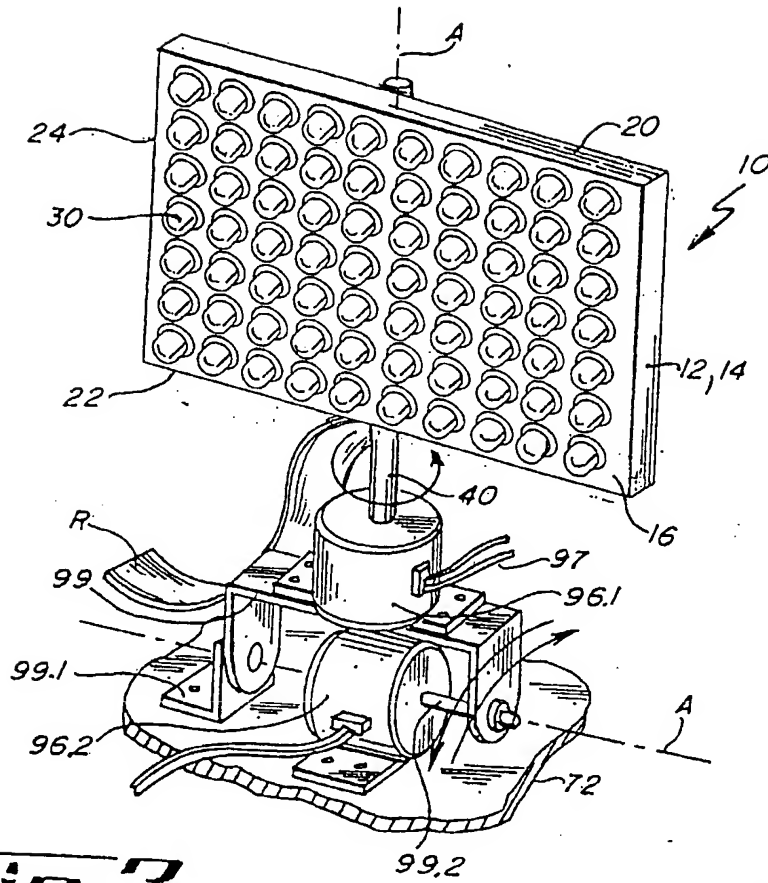


Fig. 3.

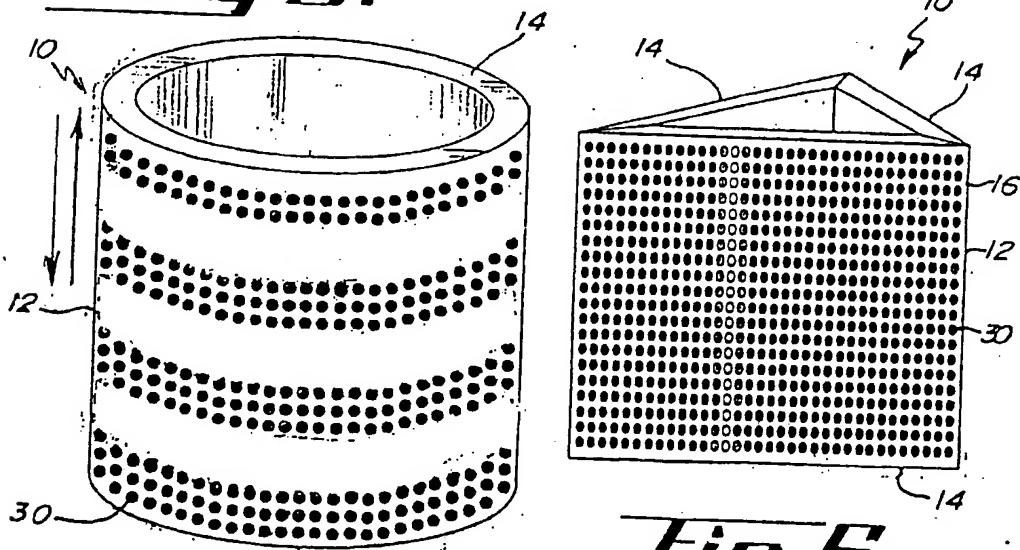


Fig. 6.

Fig. 5.

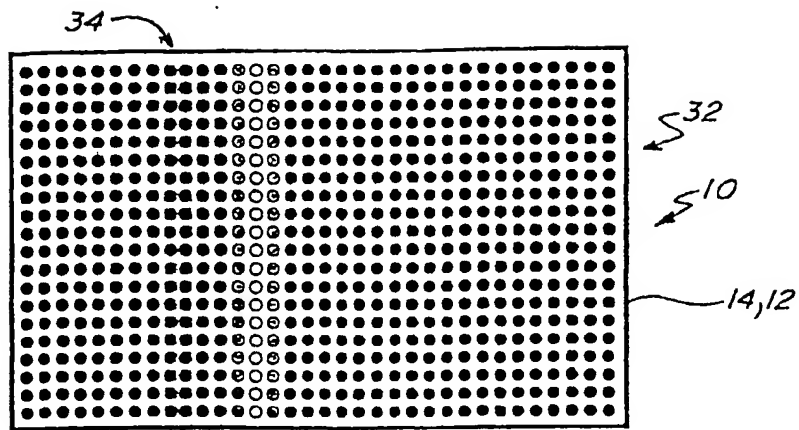


Fig. 7.

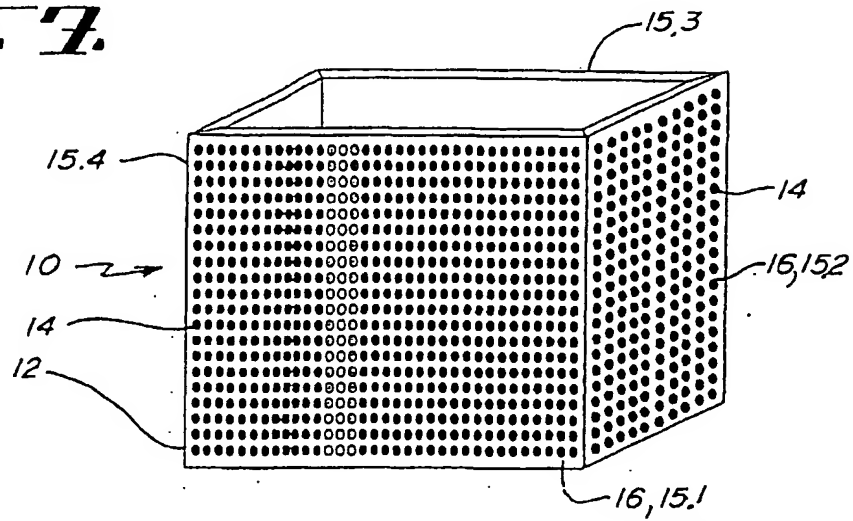


Fig. 8.

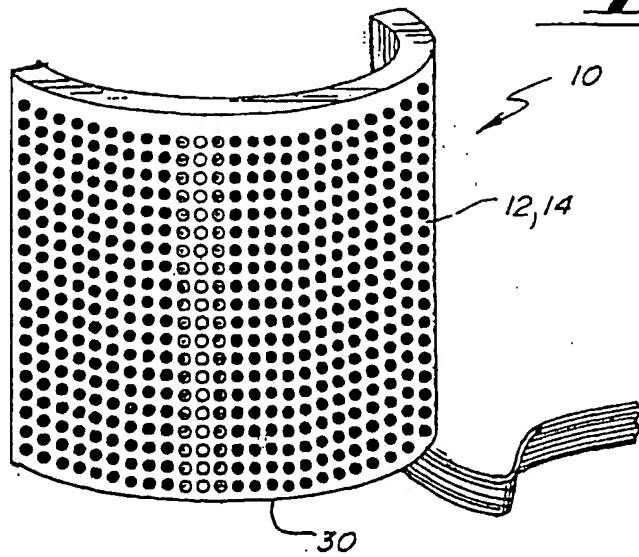
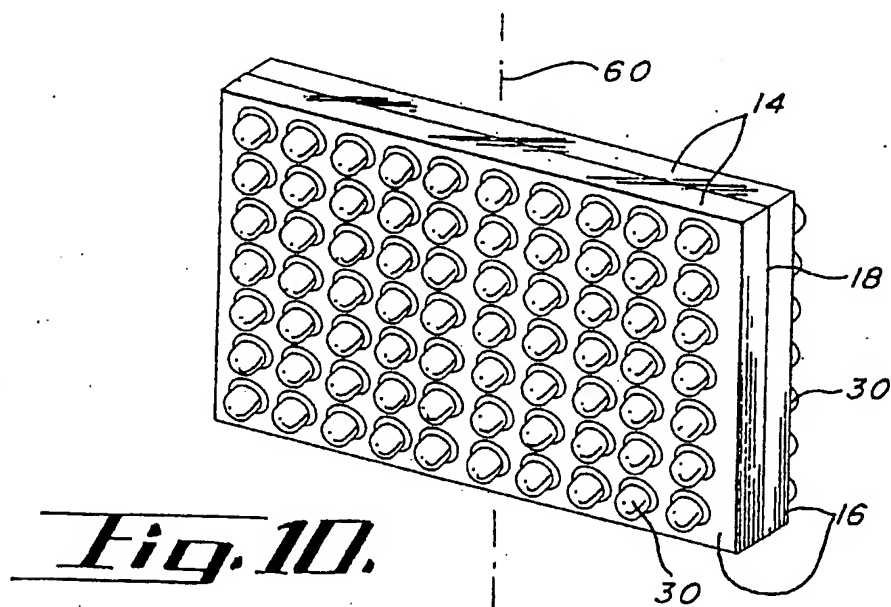
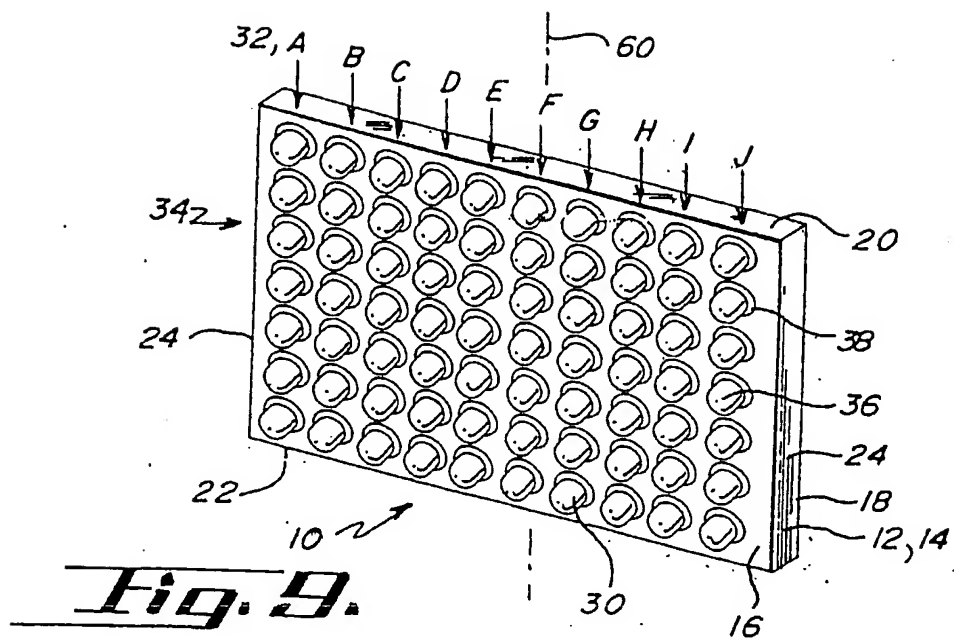


Fig. 12.



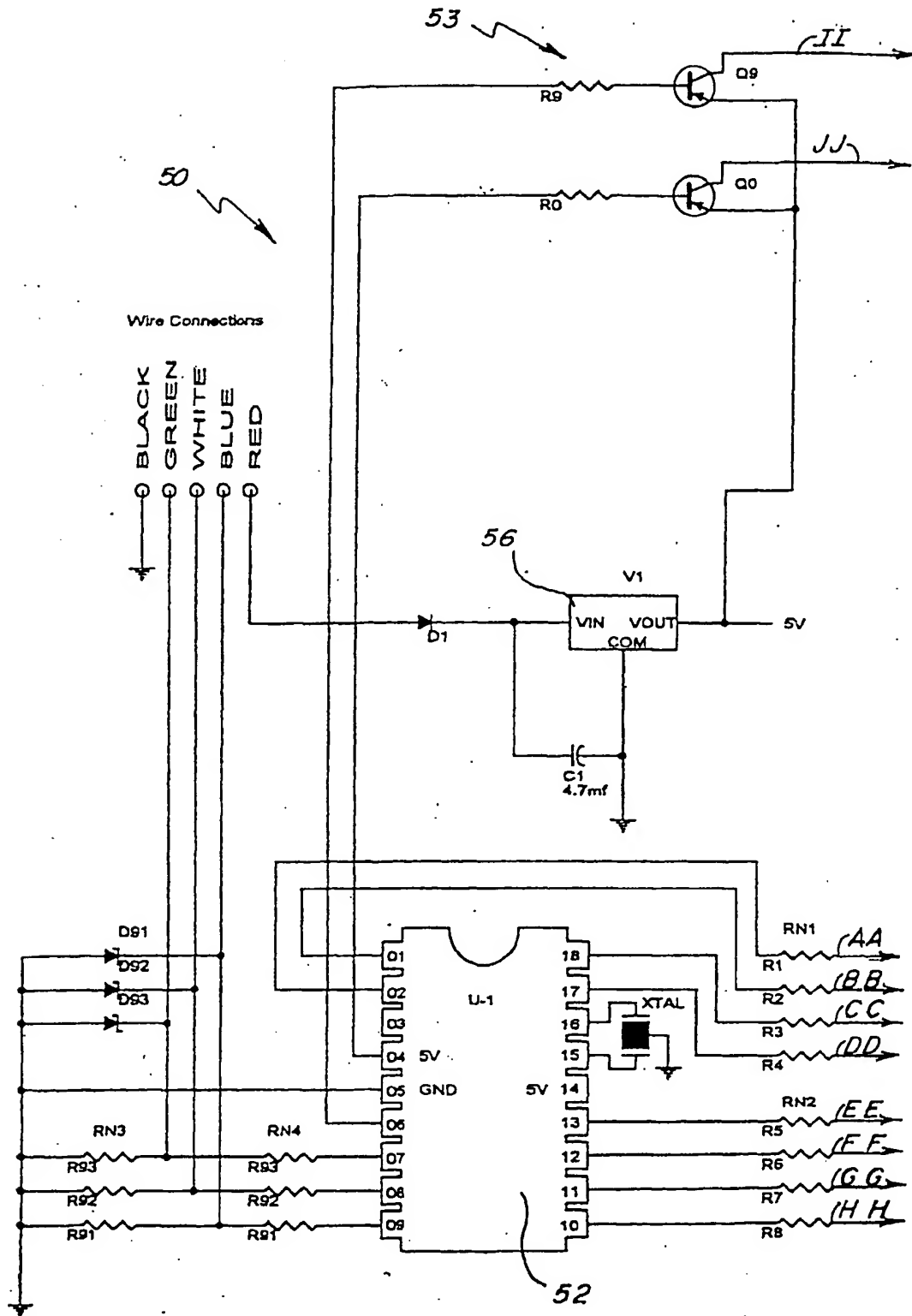


Fig. 11A

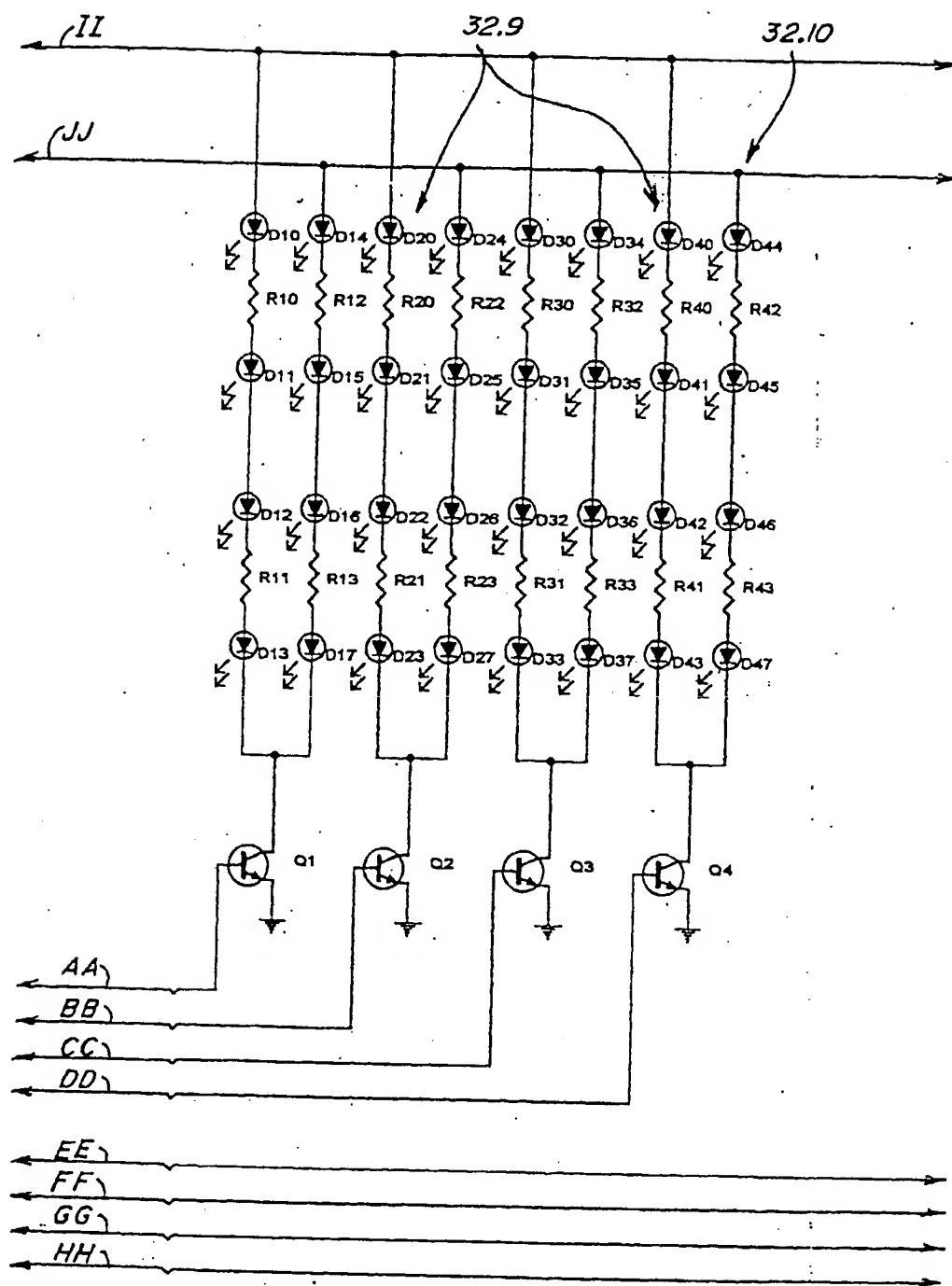


Fig. 11B.

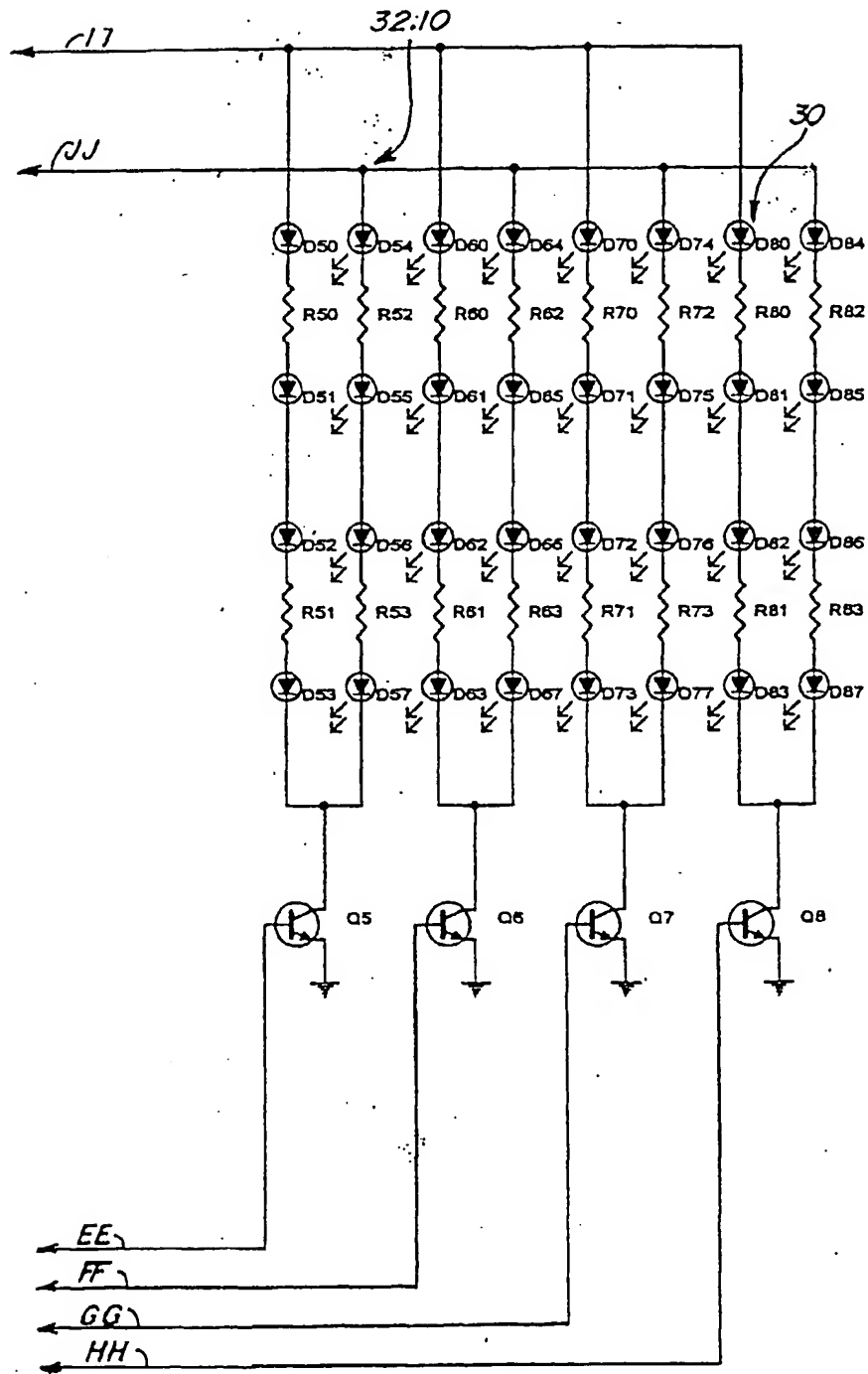


Fig. 11C.

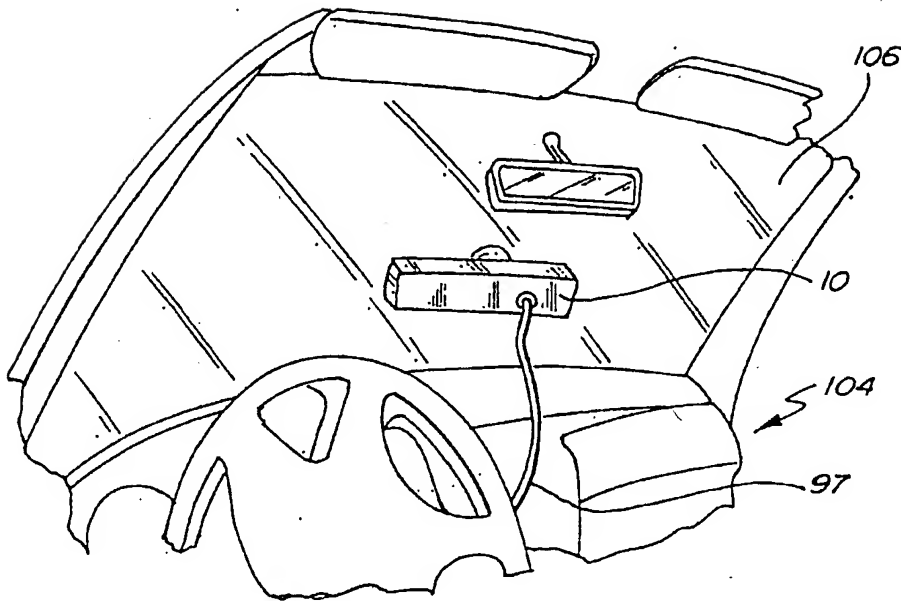


Fig. 13.

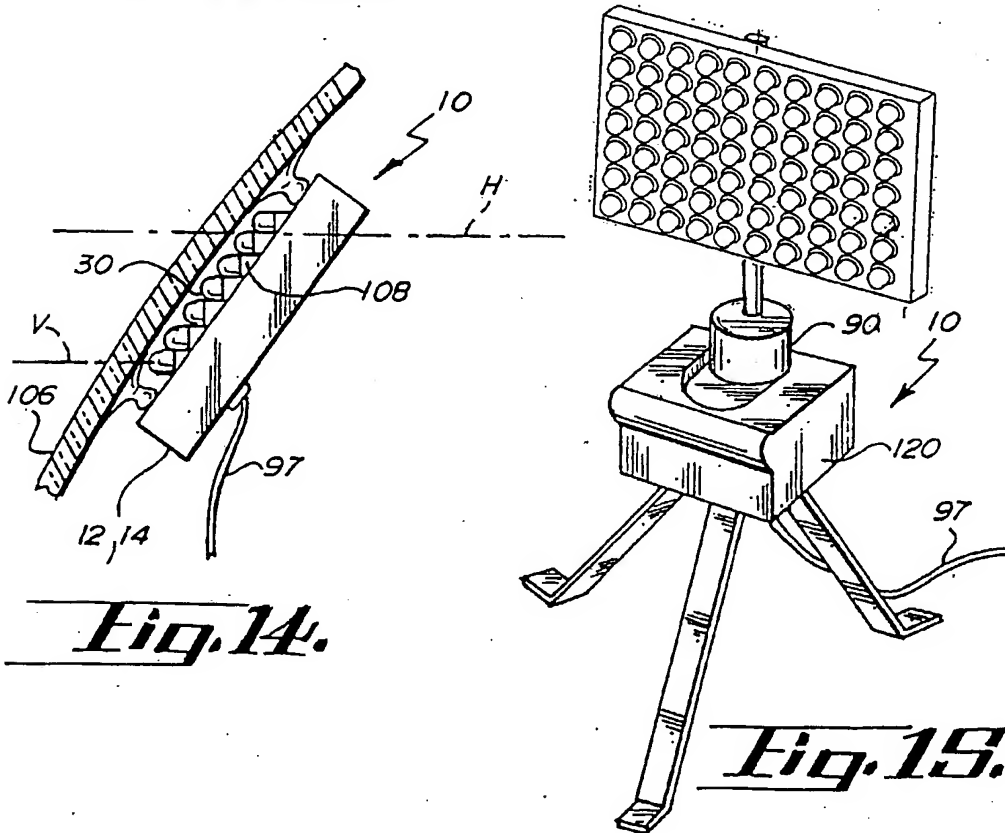


Fig. 14.

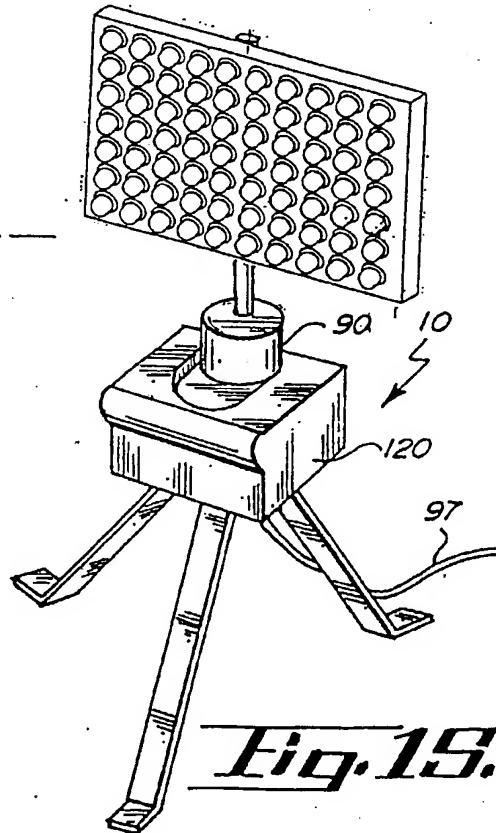


Fig. 15.

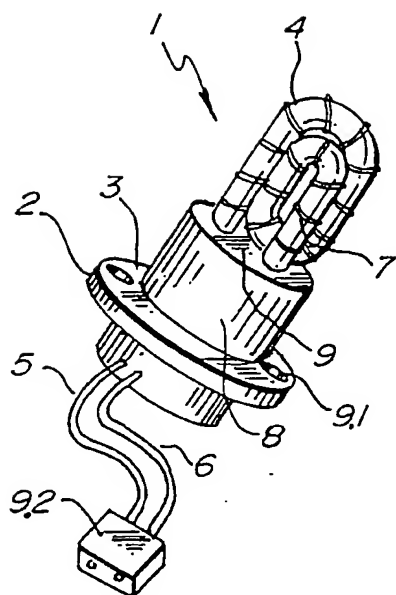


Fig. 16.
PRIOR ART

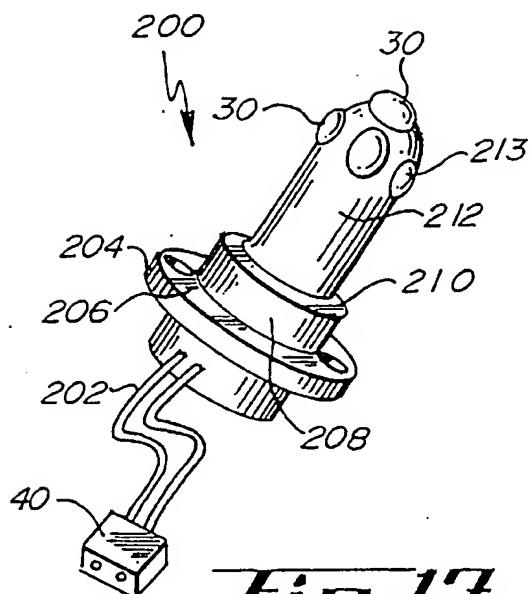


Fig. 17.

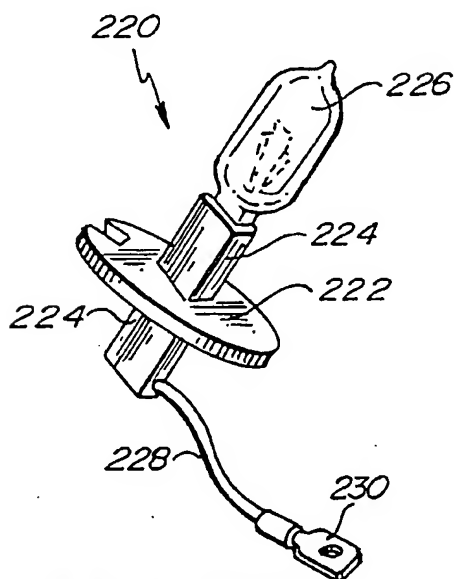


Fig. 18.
PRIOR ART

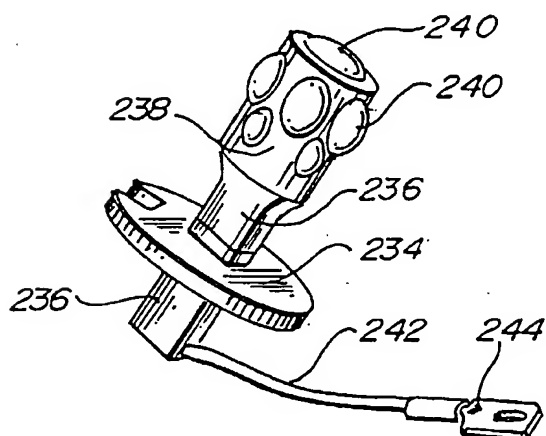


Fig. 19.

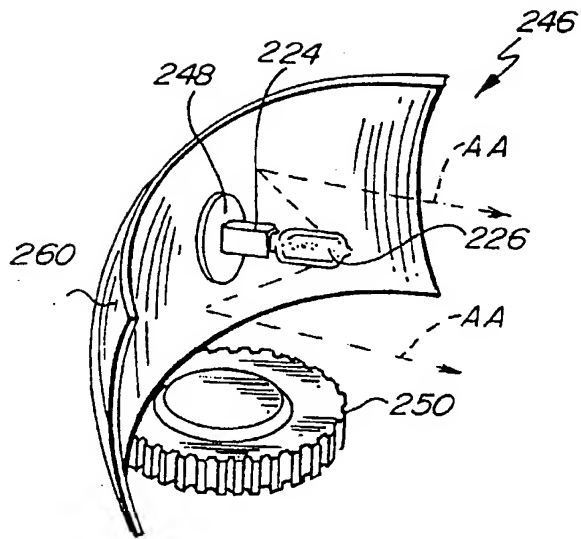


Fig. 20.
PRIOR ART

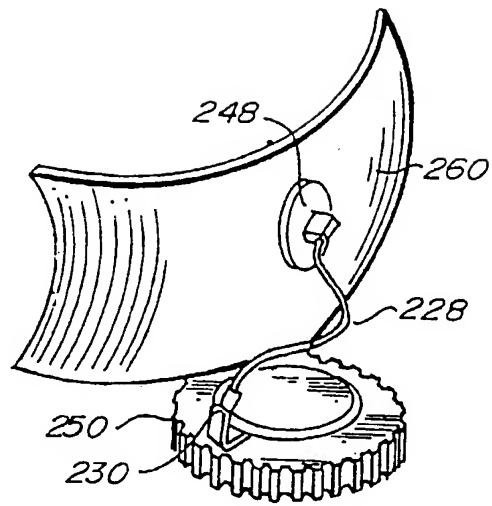


Fig. 21.

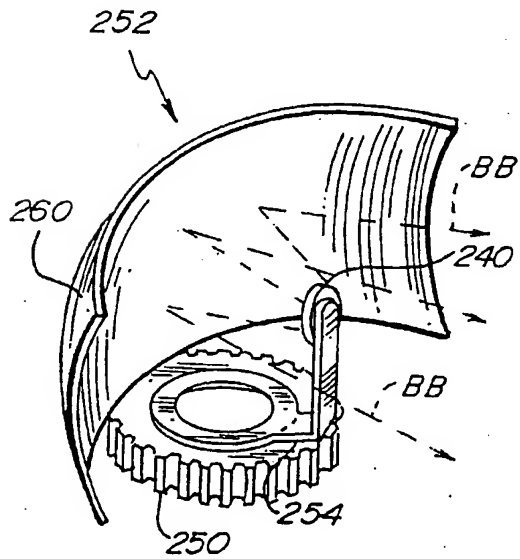


Fig. 22.

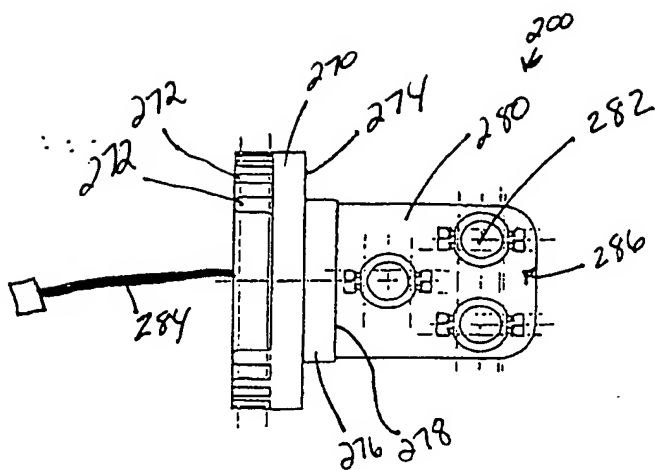


Fig. 23

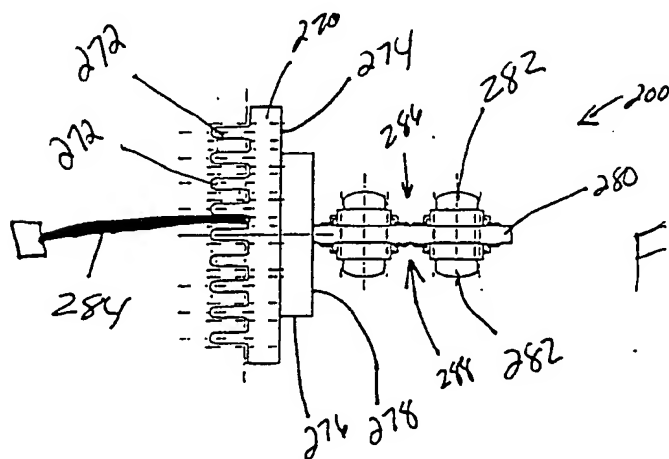


Fig. 24

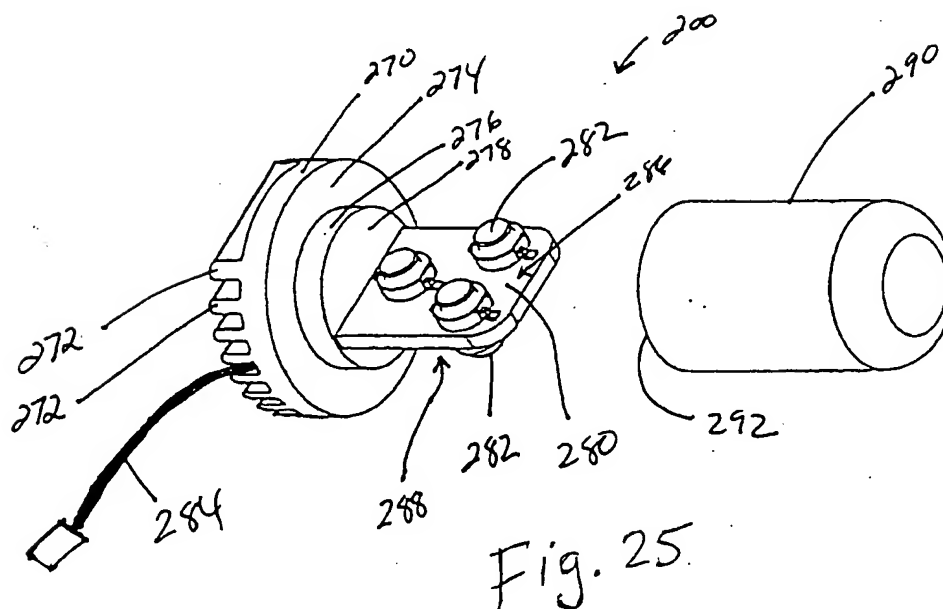


Fig. 25

